INSTRUCTIONS

MODEL 6121AEAGA5-2
EPUT METER

Electronic Services - Los Angeles
M104436X

Beckman®
INSTRUMENTS, INC.
BERKELEY DIVISION

RETURN TO

D. A. Dugan

E. Dean
A-659

MODEL 6121AEAGA5-2
EPUT METER

Beckman Instruments, Inc.
Electronic Instruments Division
2200 Wright Avenue
Richmond, California 94804

October 1966

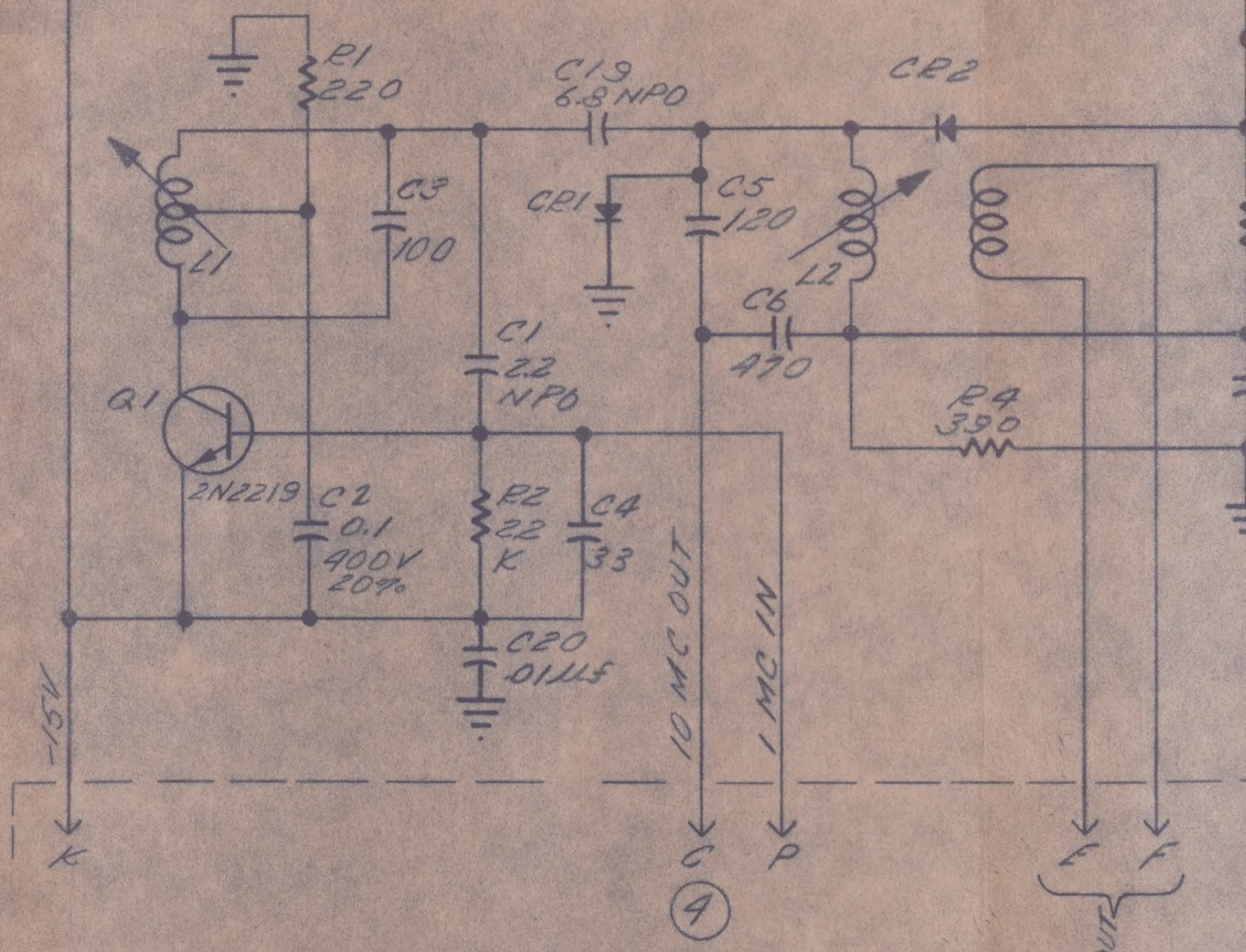
MODEL 6121AEAGA5-2
EPUT METER

The BECKMAN Model 6121AEAGA5-2 EPUT Meter is a standard BECKMAN Model 6121AEAGA5 which has been modified as follows:

A 10 Mc signal is available at a rear panel BNC labeled "10 Mc OUT". This signal is greater than 0.1v rms with a 90 ohm load.

In all other respects this instrument is standard and the following instruction manual will apply.

C887-424126



NOTE:

1.) RESISTORS; 1/4 W., 5%, OR AS NOTED.

2.) DIODES ARE TO BE IN198.

3.) L1, 3, 4, & 5 ARE B/B SPEC., 411964.
L2, 411965.

(4) TO DRIVE COUNT GATE CIRCUITRY.

(5) TO TRANFER OSCILLATOR, MUST BE 2 0.1V RMS IN-TO 90 Ω LOAD.

L5
Q2
R-9
C-30
CR-2

	6146A0-17
NEXT ASSY.	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED

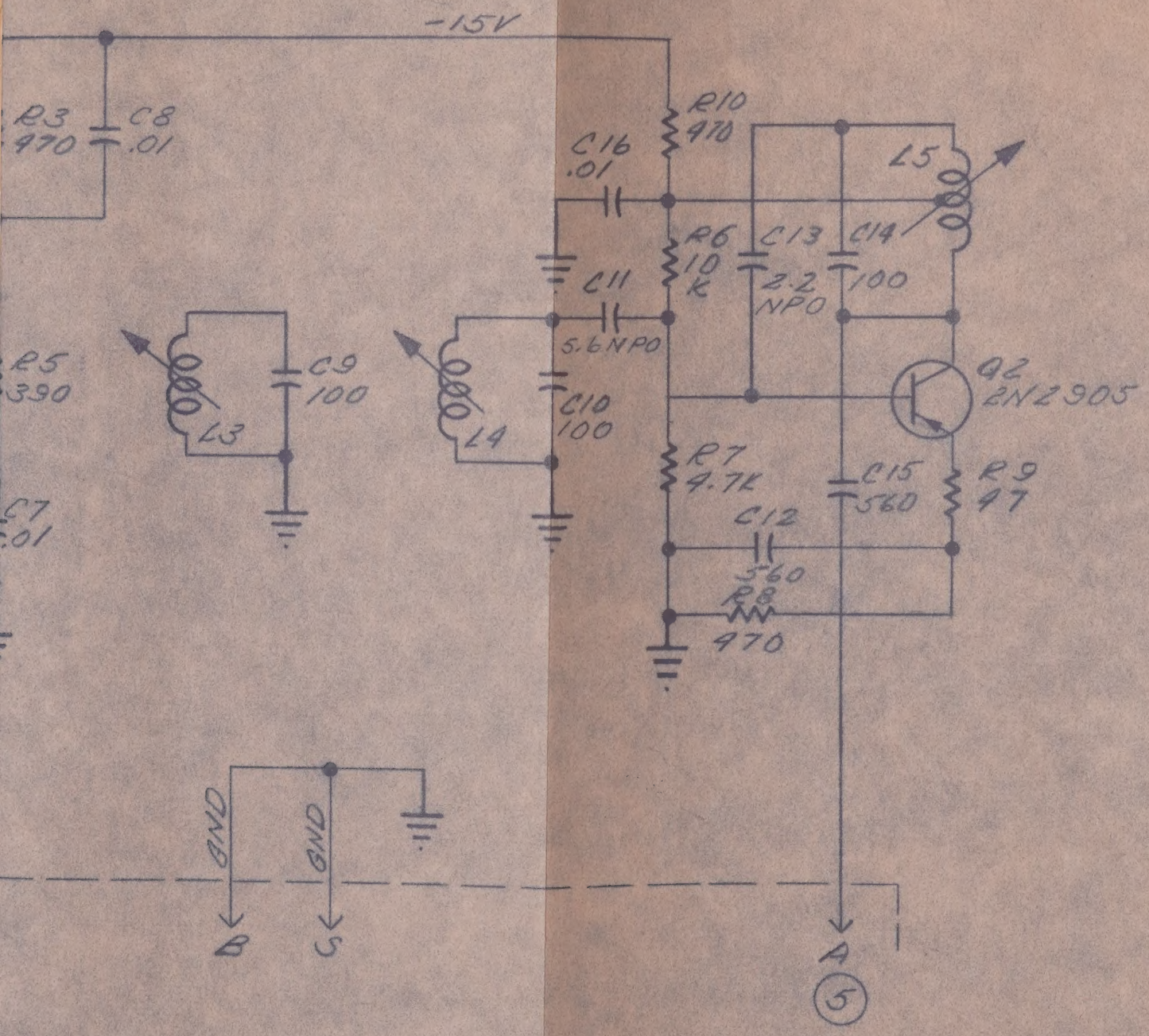
TOLERANCES

.X	±.050	ANGULAR ±0°
.XX	±.020	
.XXX	±.005	MACH. SURF.

THREADS: CLASS 2A OR 2B
REMOVE BURRS & SHARP EDGES .020 M
MACH. FILLET RADIUS .020 R MAX.
MACH. SURF. FLAT WITHIN .001 IN/IN
OTHER SURF. FLAT WITHIN .005 IN/IN
CONCENTRICITY MACH. SURF. TIR WITH
½ SUM OF DIA. TOLS., .001 MIN.

DO NOT SCALE DRAWING

B SIZE	DWG. NO.	REV	DESCRIPTION	ECO NO	DATE	BY	CHKD	APPD



ITEM	PART NO.	DESCRIPTION	QTY.

	BY	DATE
DRAWN	B. BRITT	11-64
CHKD		11/14
ENGR		11-64
APPD		
APPD		

TITLE: 1-10MC MULTIPLIER USE W/TRANSFR OSCILLATOR

MATERIAL

FINISH

SCALE

B SIZE

Beckman®

Berkeley Division, Richmond, California

THIS DOCUMENT CONTAINS PROPRIETARY INFORMATION OF BECKMAN INSTRUMENTS, INC. AND IS TENDERED SUBJECT TO THE CONDITIONS THAT THE INFORMATION (A) BE RETAINED IN CONFIDENCE, (B) NOT BE REPRODUCED OR COPIED IN WHOLE OR IN PART AND (C) NOT BE USED OR INCORPORATED IN ANY PRODUCT EXCEPT UNDER AN EXPRESS WRITTEN AGREEMENT WITH BECKMAN INSTRUMENTS, INC.

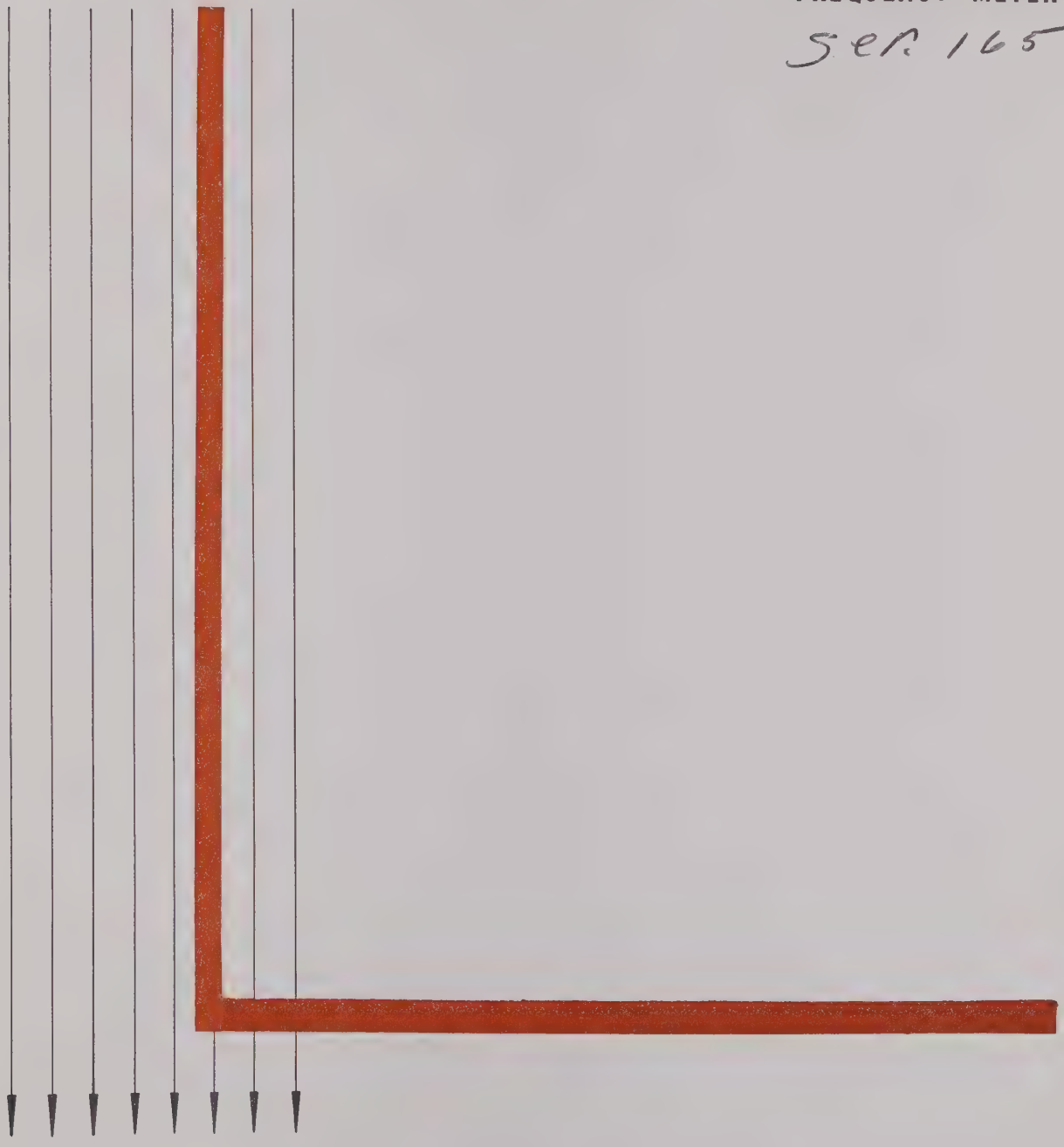
020-423782 SA

SHEET OF REV

INSTRUCTION MANUAL

MODEL 6121
FREQUENCY METER

Ser. 165



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

September 1965

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

Manual Revision

MODELS 6120 and 6121

Please note the following change under "Input Characteristics" in Table 1-1 (page 1-2):

"Sensitivity" should read: 150 mv to 1 V rms

CONTENTS

DESCRIPTION

PARTS LIST

COMPONENT LAYOUT DRAWINGS

50 Mc Input Amplifier P.C. Board	A421609
S Logic P.C. Board	C422008

DIAGRAMS

Unit Logic Schematic	D423130
Count Logic Schematic	D423129
50 Mc Input Amplifier Schematic	D421787
S Logic Schematic	D422011

APPENDICES

Model 872 DCU Instruction Manual

Model 862 DCU Instruction Manual

Model 6120 Instruction Manual

DESCRIPTION

GENERAL

The Beckman Model 6121 Frequency Meter measures frequency from 25 cps to 50 mc, and displays the measurement on a six-digit electroluminescent panel.

Except for frequency measuring range and the necessary circuit changes required to increase the range, Model 6121 is identical to Model 6120. Except as noted in the following paragraphs, all information in the 6120 instruction manual applies to the 6121.

SPECIFICATIONS

Specifications, except for frequency measuring range (25 cps to 50 mc), are identical to Model 6120. Refer to Table 1-1 of the 6120 manual.

OPERATION

Information in Section 2 of the 6120 manual applies directly to Model 6121.

CIRCUITS

Except for the differences noted in Table 1, Models 6121 and 6120 contain the same printed circuit boards.

Table 1. Printed Circuit Board Differences

P. C. Board No.	Model 6120	Model 6121
A1	870 DCU	872 DCU
A3	860 DCU	862 DCU
A5	850 DCU	860 DCU
A18	25 Mc Amplifier	50 Mc Amplifier
A26	F Logic	S Logic

SERVICING

Adjustment procedures contained in the Model 6120 manual apply directly to Model 6121.

PARTS LIST

The parts list for the Model 6121 follows.

NOTE

Except for the following, the parts list for Model 6120 applies to Model 6121:

Deletions: Model 870 DCU (P. C. Board A1) (appended manual in 6020 manual).
25 Mc Input Amplifier (P. C. Board A18).
F Logic (P. C. Board A26).

Additions: Model 872 DCU (P. C. Board A1).
Model 862 DCU (P. C. Board A3).
50 Mc Input Amplifier (P. C. Board A18).
S Logic (P. C. Board A26).

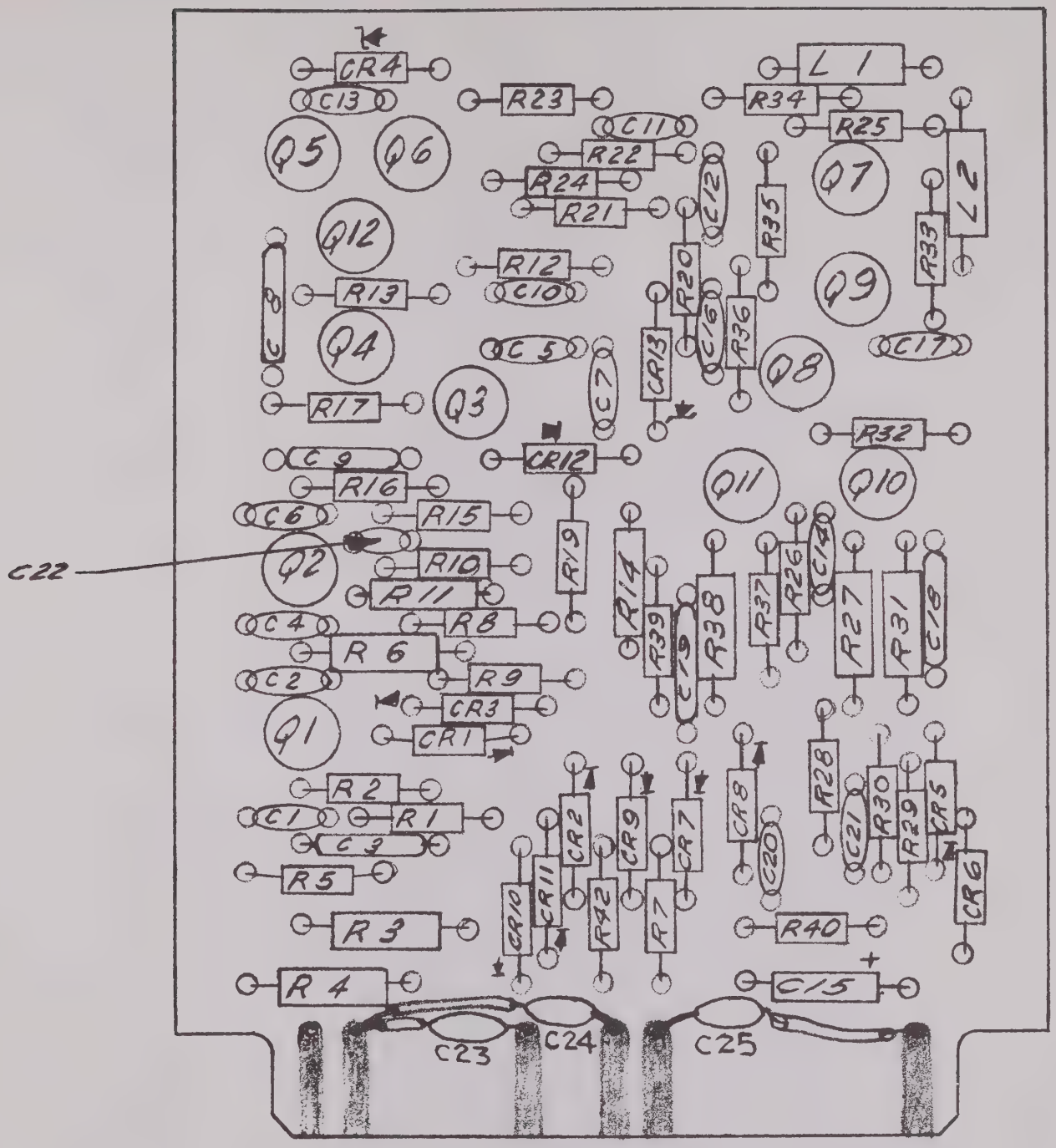
Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
A1	887-416902	Model 872 DCU Refer to appended manual	Beckman/Berkeley	1
A3	887-416903	Model 862 DCU Refer to appended manual	B/B	1
A18	887-421609	50 MC INPUT AMPLIFIER	B/B	1
A18C1	633-804715	Capacitor, F. Cerm., 0.01μf, 50V	Sprague 19C214	18
A18C2		Same as A1C1		
A18C3	637-824028	Capacitor, F. Mica, 1000pf, 300V, 5%	Elmenco DM16E102J-300	1
A18C4 thru A18C7		Same as A1C1		
A18C8	637-824004	Capacitor, F. Mica, 10pf, 300V, 5%	Arco DM16C100J-300	1
A18C9	637-824001	Capacitor, F. Mica, 5.6pf, 300V, 5%	Elmenco DM16C056J-300	1
A18C10 thru A18C14		Same as A1C1		
A18C15	631-802980	Capacitor, F. Elect., 22μf, 25V, 20%	Sprague 1090226X0025C2	1
A18C16 & A18C17		Same as A1C1		
A18C18	637-824012	Capacitor, F. Mica, 47pf, 300V, 5%	Arco DM16E470J-300	1
A18C19	637-824016	Capacitor, F. Mica, 100pf, 300V, 5%	Arco DM16E101J-300	1
A18C20 & A18C21		Same as A1C1		
A18C22	637-822756	Capacitor, F. Mica, 15pf, 300V, 5%	Elmenco DM15C150K-300	1
A18C23 thru A18C25		Same as A1C1		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Assy.
A18CR1	755-815561	Diode, Silicon, 75PIV, 10 ma, 1V min. fwd.	Fairchild 1N3064	10
A18CR2 & A18CR3		Same as A18CR1		
A18CR4	755-819903	Diode, Zener, 10 ma, 7.0V, 5%	Transistron 1N763	1
A18CR5		Same as A18CR1		
A18CR6	755-817250	Diode, Germanium, 6PIV, 200 ma, 1V min. fwd.	Inter. Rec. Q6-100	1
A18CR7 thru A18CR12		Same as A18CR1		
A18CR13	755-822549	Diode, Zener, 8.2V, 400 mw, 10%	Motorola 1N756A	1
A18L1	795-819899	Inductor, Fixed, R.F., 0.22μh	Delevan 1840-02	2
A18L2		Same as A18L1		
A18Q1	755-417481	Transistor, Selected, 2N709	B/B	6
A18Q2		Same as A18Q1		
A18Q3	755-836485	Transistor, Germanium, PNP, 250mw, min.	Texas Inst. 2N2374	1
A18Q4	755-413996	Transistor, Special	B/B	3
A18Q5 & A18Q6		Same as A18Q1		
A18Q7 & A18Q8		Same as A18Q4		
A18Q9 & A18Q10		Same as A18Q1		
A18Q11	755-419596	Transistor, Special	B/B	2
A18Q12		Same as A18Q11		
A18R1	601-822324	Resistor, F. Comp., 10K, 1/4W, 5%	Allen Bradley CB1035	1
A18R2	601-823908	Resistor, F. Comp., 220K, 1/4W, 5%	Allen Bradley CB2245	1
A18R3	601-015050	Resistor, F. Comp., 5.6K, 1/2W, 5%	Allen Bradley EB5625	2
A18R4		Same as A18R3		
A18R5	601-822335	Resistor, F. Comp., 27K, 1/4W, 5%	Allen Bradley CB2735	1
A18R6	601-008129	Resistor, F. Comp., 1.5K, 1/2W, 5%	Allen Bradley EB1525	1
A18R7	601-822295	Resistor, F. Comp., 2.7K, 1/4W, 5%	Allen Bradley CB2725	2
A18R8	601-xxxxxx	Resistor, Factory Selected Value		1
A18R9	601-822306	Resistor, F. Comp., 820Ω, 1/4W, 5%	Allen Bradley CB8215	2
A18R10		Same as A18R9		
A18R11	601-015442	Resistor, F. Comp., 150Ω, 1/2W, 5%	Allen Bradley ER1515	1
A18R12	601-822308	Resistor, F. Comp., 1K, 1/4W, 5%	Allen Bradley CB1025	1
A18R13	601-822375	Resistor, F. Comp., 82Ω, 1/4W, 5%	Allen Bradley CB8205	1
A18R14	601-xxxxxx	Resistor, Factory Selected Value		1
A18R15	601-822327	Resistor, F. Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	3
A18R16	601-822371	Resistor, C. Comp., 390Ω, 1/4W, 5%	Allen Bradley CB3915	1
A18R17	601-823394	Resistor, F. Comp., 330Ω, 1/4W, 5%	Allen Bradley CB3315	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A18R19	601-079172	Resistor, F. Comp., 820Ω, 1/2W, 5%	Allen Bradley EB8215	1
A18R20	601-823389	Resistor, F. Comp., 68Ω, 1/4W, 5%	Allen Bradley CB6805	1
A18R21	601-822527	Resistor, F. Comp., 1.5K, 1/4W, 5%	Allen Bradley CB1525	1
A18R22	601-823390	Resistor, F. Comp., 120Ω, 1/4W, 5%	Allen Bradley CB1215	2
A18R23		Same as A18R15		
A18R24	601-823917	Resistor, F. Comp., 10Ω, 1/4W, 10%	Allen Bradley CB1001	1
A18R25		Same as A18R22		
A18R26		Same as A18R15		
A18R27	601-015449	Resistor, F. Comp., 1.8K, 1/2W, 5%	Allen Bradley EB1825	1
A18R28	601-822460	Resistor, F. Comp., 3.9K, 1/4W, 5%	Allen Bradley CB3925	1
A18R29	601-822296	Resistor, F. Comp., 3.3K, 1/4W, 5%	Allen Bradley CB3325	1
A18R30	601-822334	Resistor, F. Comp., 22K, 1/4W, 5%	Allen Bradley CB2235	1
A18R31	601-015038	Resistor, F. Comp., 1K, 1/2W, 5%	Allen Bradley EB1025	1
A18R32	601-823393	Resistor, F. Comp., 270Ω, 1/4W, 5%	Allen Bradley CB2715	2
A18R33		Same as A18R32		
A18R34	601-822369	Resistor, F. Comp., 680Ω, 1/4W, 5%	Allen Bradley CB6815	1
A18R35	601-823394	Resistor, F. Comp., 330Ω, 1/4W, 5%	Allen Bradley CB3315	1
A18R36	601-823387	Resistor, F. Comp., 47Ω, 1/4W, 5%	Allen Bradley CB4705	1
A18R37	601-817735	Resistor, F. Comp., 100Ω, 1/4W, 5%	Allen Bradley CB1015	2
A18R38	601-015039	Resistor, F. Comp., 1.2K, 1/2W, 5%	Allen Bradley EB1225	1
A18R39	601-822301	Resistor, F. Comp., 15K, 1/4W, 5%	Allen Bradley CB1535	1
A18R40		Same as A18R37		
A18R42		Same as A18R7		
A26	887-422008	S LOGIC	B/B	1
A26C1	633-804715	Capacitor, F. Cerm., 0.01μf, 50V, -20+80%	Sprague 19C214	9
A26C2	637-824009	Capacitor, F. Mica, 27pf, 300V, 5%	Electromotive DM16C270J-300	1
A26C3	637-824013	Capacitor, F. Mica, 56pf, 300V, 5%	Electromotive DM16E560J-300	3
A26C4 & A26C5		Same as A26C1		
A26C6	637-824004	Capacitor, F. Mica, 10pf, 300V, 5%	Electromotive DM16C100J-300	1
A26C7		Same as A26C1		
A26C8	637-824011	Capacitor, F. Mica, 39pf, 300V, 5%	Electromotive DM16E390J-300	1
A26C9		Same as A26C1		
A26C10		Same as A26C3		
A26C11	631-802980	Capacitor, F. Elect., 22μf, 25V	Sprague 109D226X0023C2	1
A26C12	637-824007	Capacitor, F. Mica, 18pf, 300V, 5%	Electromotive DM16C180J-300	1

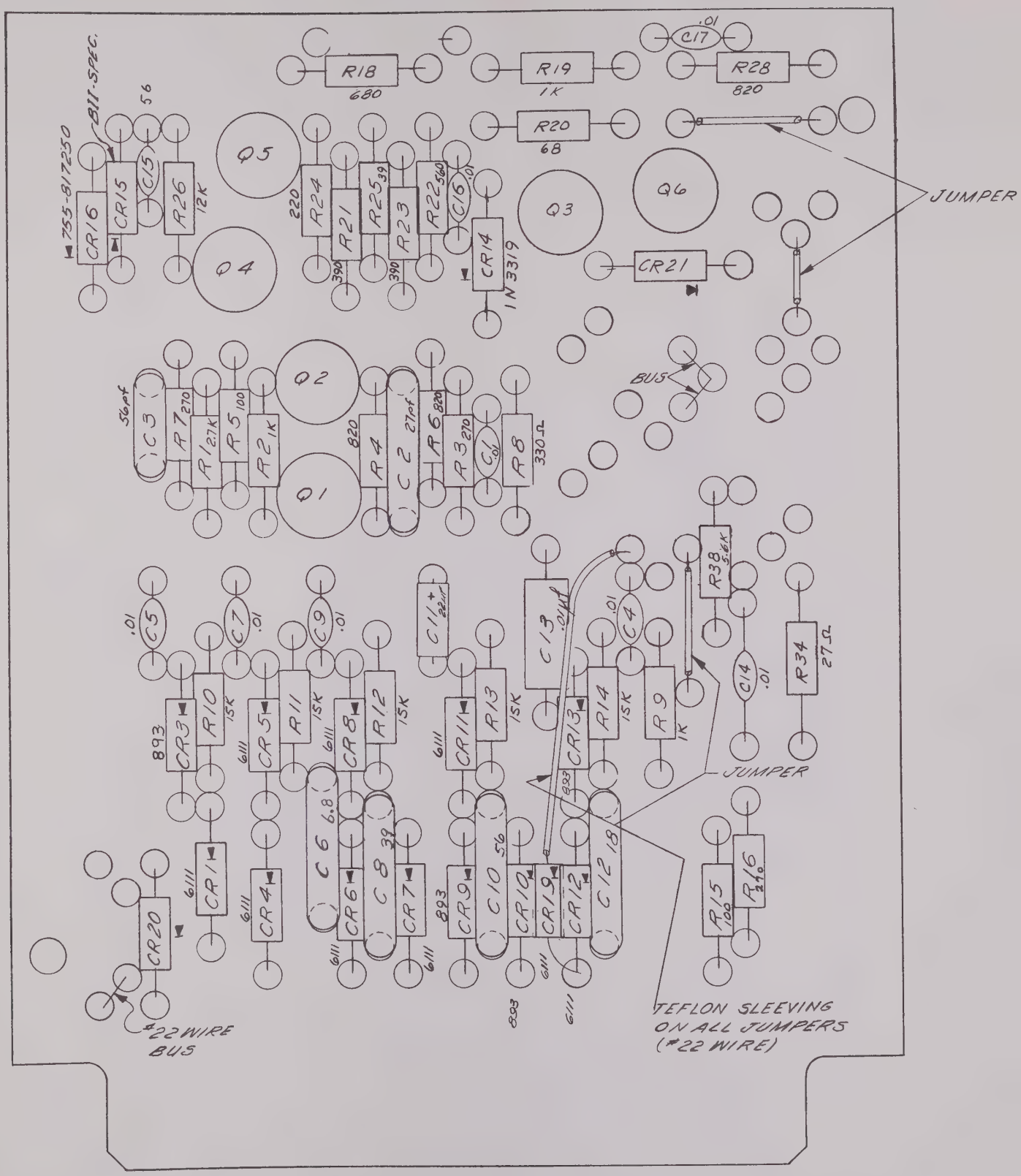
Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A26C13 & A26C14		Same as A26C1		
A26C15		Same as A26C3		
A26C16 & A26C17		Same as A26C1		
A26CR1	755-815561	Diode, Silicon, 75PIV, 10ma, 1V, min. fwd.	B/B	10
A26CR3	755-420893	Diode, Germanium, Fast Switching	B/B	4
A26CR4 thru A26CR8		Same as A26CR1		
A26CR9 & A26CR10		Same as A26CR3		
A26CR11 & A26CR12		Same as A26CR1		
A26CR14	755-811280	Diode, Reference, Silicon, 5V min., 5.5V max.	Cont. Device CD3319	1
A26CR15	755-817250	Diode, Germanium, 6PIV, 200ma, 1V, min. fwd.	Inter. Rec. Q6-100	3
A26CR16		Same as A26CR15		
A26CR18		Same as A26CR3		
A26CR19		Same as A26CR1		
A26CR20		Same as A26CR15		
A26CR21		Same as A26CR1		
A26Q1	755-817811	Transistor, Germanium, PNP, 150mw, max.	Motorola 2N961	5
A26Q2 thru A26Q4		Same as A26Q1		
A26Q5	755-819907	Transistor, Silicon, NPN, 200mw	Motorola 2N918	1
A26Q6		Same as A26Q1		
A26R1	601-822295	Resistor, F. Comp., 2.7K, 1/4W, 5%	Allen Bradley CB2725	1
A26R2	601-822308	Resistor, F. Comp., 1K, 1/4W, 5%	Allen Bradley CB1025	3
A26R3	601-823393	Resistor, F. Comp., 270Ω, 1/4W, 5%	Allen Bradley CB2715	3
A26R4	601-822306	Resistor, F. Comp., 820Ω, 1/4W, 5%	Allen Bradley CB8215	3
A26R5	601-817735	Resistor, F. Comp., 100Ω, 1/4W, 5%	Allen Bradley CB1015	2
A26R6		Same as A26R4		
A26R7		Same as A26R3		
A26R8	601-823394	Resistor, F. Comp., 330Ω, 1/4W, 5%	Allen Bradley CB3345	1
A26R9		Same as A26R2		
A26R10	601-822301	Resistor, F. Comp., 15K, 1/4W, 5%	Allen Bradley CB1535	5
A26R11 thru A26R14		Same as A26R10		
A26R15		Same as A26R5		
A26R16		Same as A26R3		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A26R18	601-822369	Resistor, F. Comp., 680Ω, 1/4W, 5%	Allen Bradley CB6815	2
A26R19		Same as A26R18		
A26R20	601-823389	Resistor, F. Comp., 68Ω, 1/4W, 5%	Allen Bradley CB6805	1
A26R21	601-822371	Resistor, F. Comp., 390Ω, 1/4W, 5%	Allen Bradley CB3915	2
A26R22	601-823396	Resistor, F. Comp., 560Ω, 1/4W, 5%	Allen Bradley CB5615	1
A26R23		Same as A26R21		
A26R24	601-822327	Resistor, F. Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	1
A26R25	601-823386	Resistor, F. Comp., 39Ω, 1/4W, 5%	Allen Bradley CB3905	1
A26R26	601-801803	Resistor, F. Comp., 12K, 1/4W, 5%	Allen Bradley CB1235	1
A26R28		Same as A26R4		
A26R34	601-823384	Resistor, F. Comp., 27Ω, 1/4W, 5%	Allen Bradley CB2705	1
A26R38	601-822299	Resistor, F. Comp., 6.8K, 1/4W, 5%	Allen Bradley CB6825	1



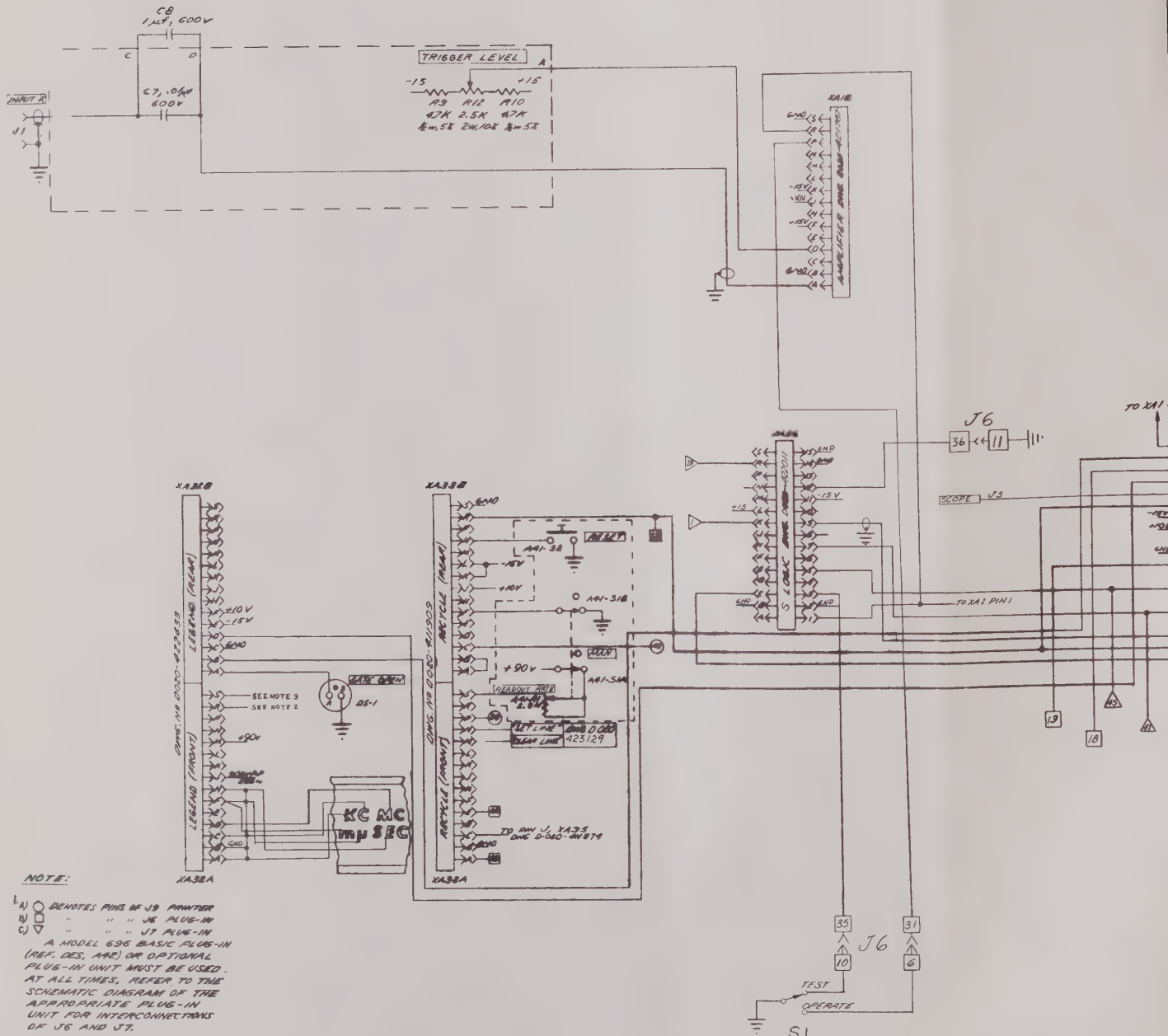
50 MC INPUT AMPLIFIER P.C. BOARD

Beckman



S LOGIC P.C. BOARD

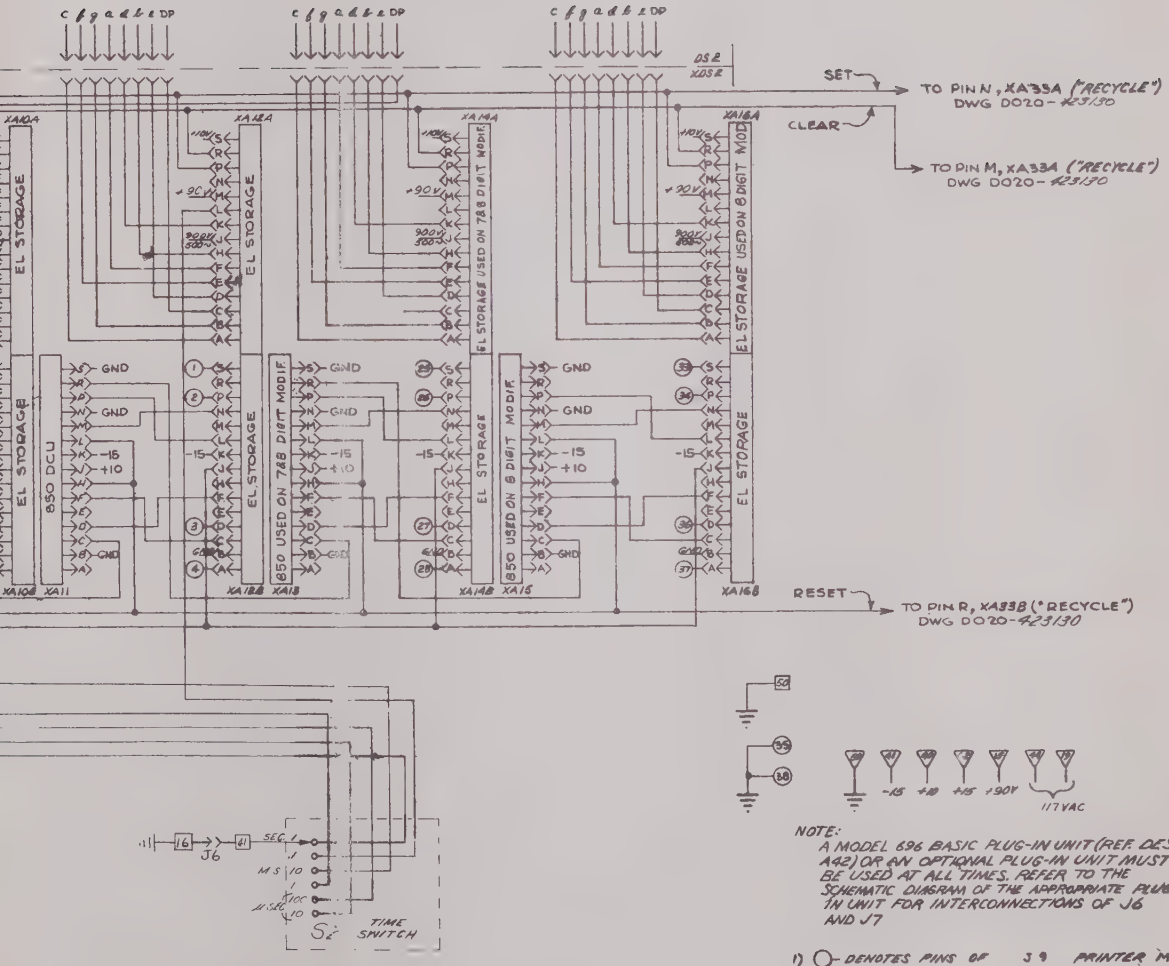
Beckman®



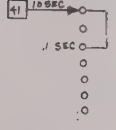
NOTE:

1. A) ○ DENOTES PINS OF J9 PRINTER
   B) ⊓ " " " J6 PLUG-IN
   C) ▽ " " " J7 PLUG-IN
   A MODEL 696 BASIC PLUG-IN (REF. DES. AAE) OR OPTIONAL PLUG-IN UNIT MUST BE USED. AT ALL TIMES, REFER TO THE SCHEMATIC DIAGRAM OF THE APPROPRIATE PLUG-IN UNIT FOR INTERCONNECTIONS OF J6 AND J7.
2. ADDED ONLY IN 10SEC MOD., TO S-2 C PIN 6
3. PIN 5 TO S-2 - C1 THRU 5 STRAPPING ON 10 SEC. MOD
4. ADDED TO S-2 ON 10 SEC. MOD. ONLY

MODEL 6121
COUNT LOGIC
SCHEMATIC DIAGRAM



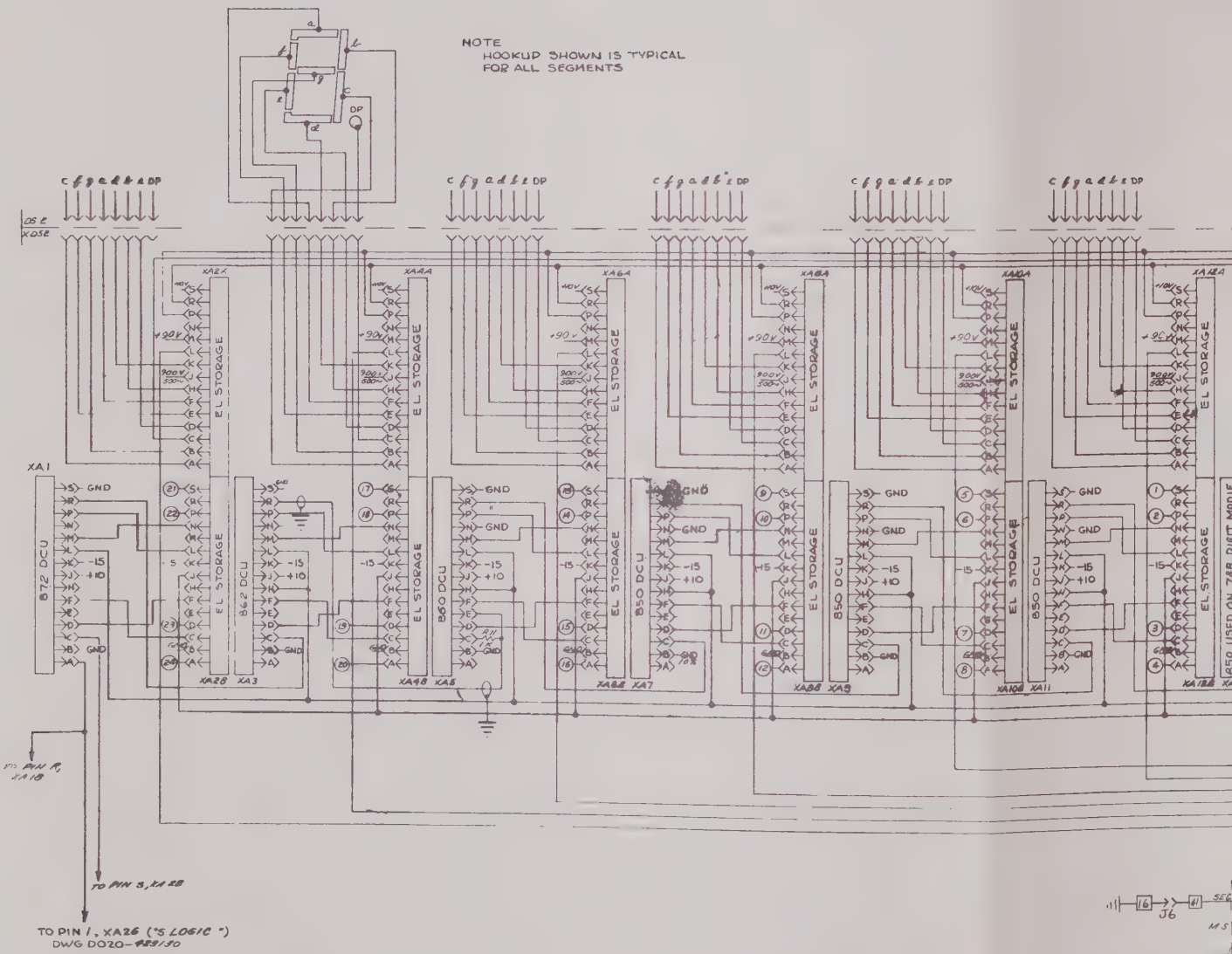
5 WHEN .1 SEC. MOD IS INSTALLED - 10 SEC. POSITION ON SWITCH PART NO. 711-810815 IS JUMPED TO .1 SEC.

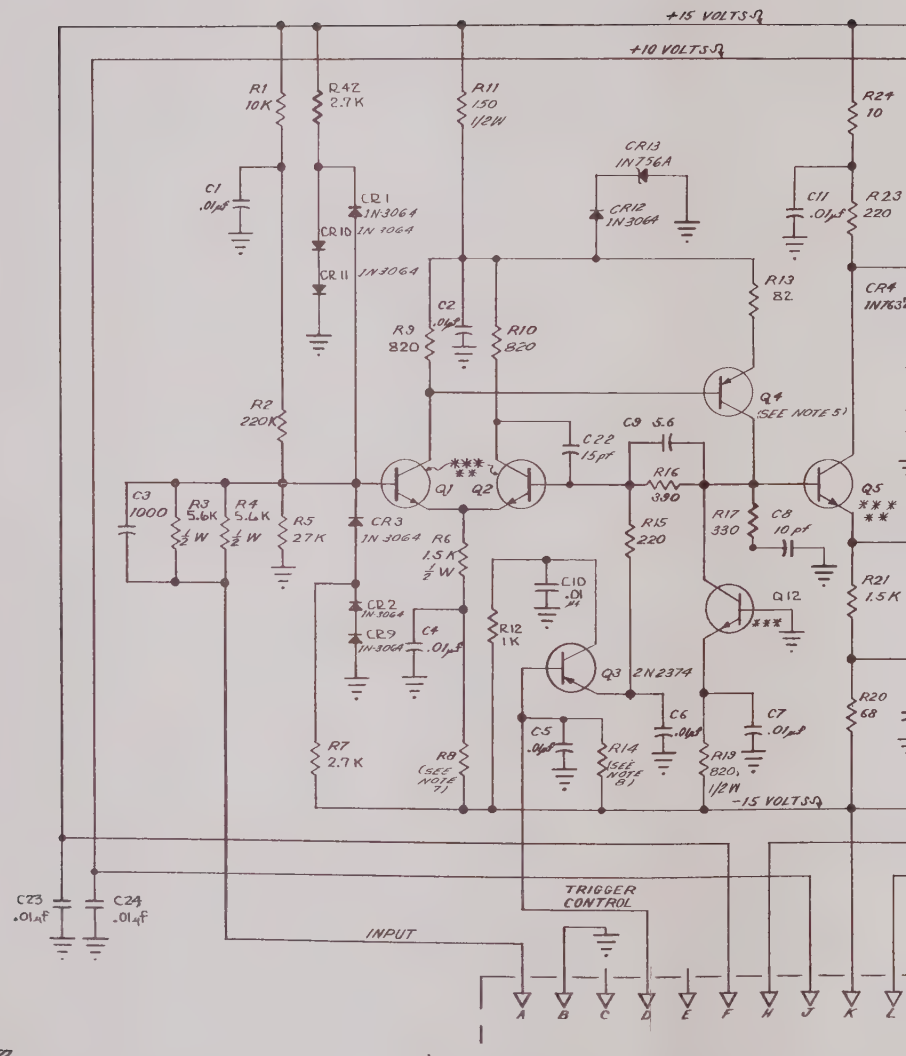


NOTE:
A MODEL 696 BASIC PLUG-IN UNIT (REF. DES. A42) OR AN OPTIONAL PLUG-IN UNIT MUST BE USED AT ALL TIMES. REFER TO THE SCHEMATIC DIAGRAM OF THE APPROPRIATE PLUG-IN UNIT FOR INTERCONNECTIONS OF J6 AND J7

1) ○ DENOTES PINS OF J9 PRINTER MOD.
2) □ " " " J6 PLUG-IN
3) ▷ " " " J7 PLUG-IN

Beckman


NOTE
HOOKUP SHOWN IS TYPICAL
FOR ALL SEGMENTS
c f g a d b e DP
EL STORAGE
850 DCU
862 DCU
872 DCU
GND
-15
+10
+90V
TO PIN 3, XA28
TO PIN 1, XA26 ("5 LOGIC")
DWG D020-459150



NOTE:

1) RESISTORS:
   WATTAGE ——— ¼ W., UNLESS NOTED.
   TOLERANCE ——— 5% , " " .
2) CAPACITORS:
   CAPACITY ——— IN PF , " " .
   VOLTAGE ——— 300 V. , " " .
   TOLERANCE ——— 5% , " " .
3) .01μf DISC. ARE -20+80%, 50 V.

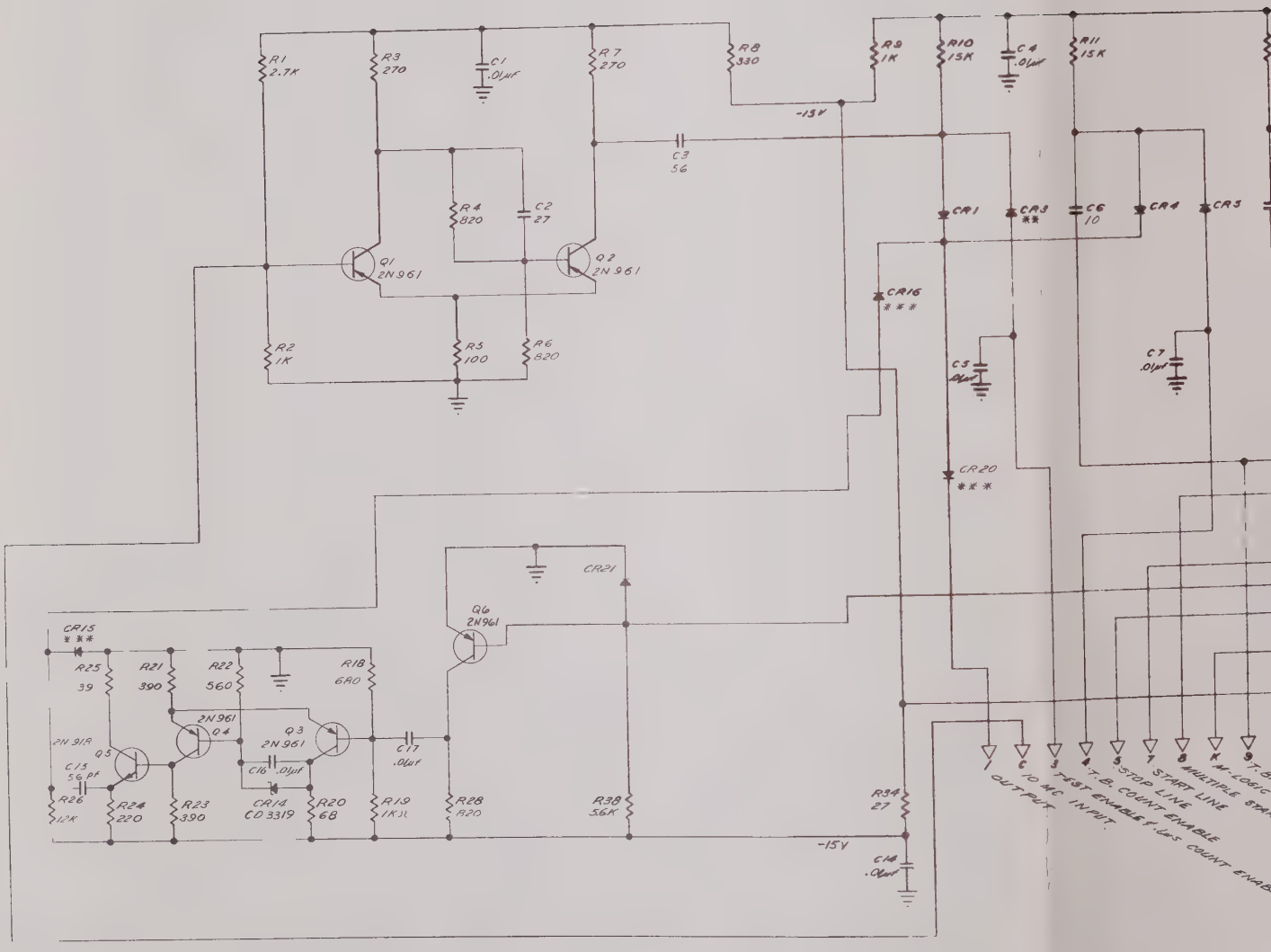
4) *** — TRANSISTORS ARE TO BECKMAN SPEC. DWG. A755-419596.

5) TRANSISTOR-IS TO BECKMAN SPEC. #755-413996

6) ***** — TRANSISTOR ARE TO BECKMAN SPEC. #755-417481

7) R8 - TYP. 680 TO 1.5K VALUE VARIATION, TO BE SELECTED WHEN CHECKING AMPLIFIER DYNAMIC RANGE AT AN INPUT FREQUENCY ABOVE 50 MC.

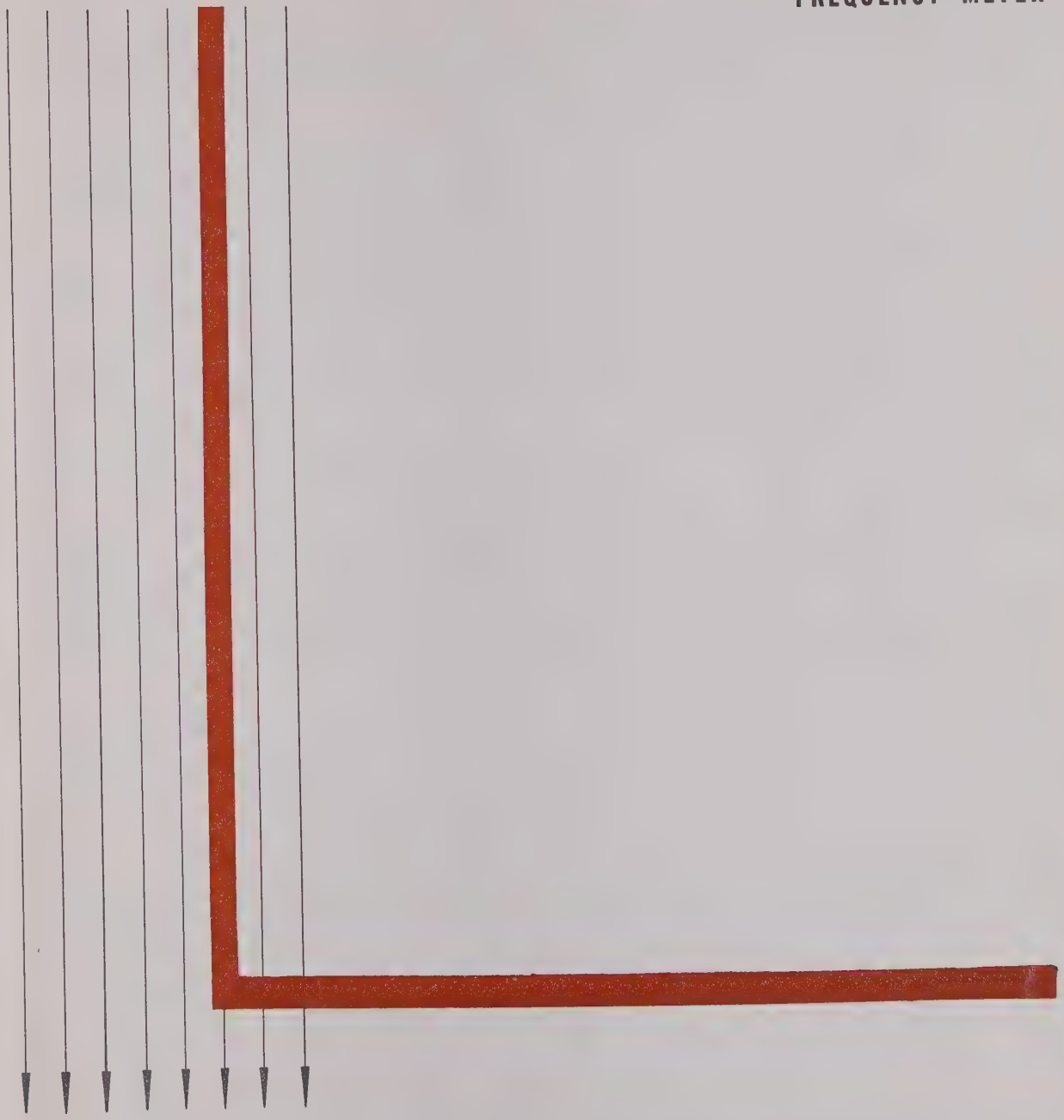
8) R14 - TYP. 18K - 39K VALUE VARIATION; CENTRE TRIGGER POT., AC OR DC., THEN SELECT R14 FOR OPTIMUM TRIGGERING OF THE AMPLIFIER (FREQUENCY-INDEPENDENT)


R1 2.7K
R3 270
C1 .01μf
R7 270
R8 330
R9 1K
R10 15K
C4 .01μf
R11 15K
-13V
C3 56
R4 820
C2 27
Q1 2N961
Q2 2N961
R2 1K
R5 100
R6 820
CR1
CR3 **
C6 10
CR4
CR3
CR16 ***
C5 .01μf
C7 .01μf
CR20 ***
CR21
Q6 2N961
CR15 ***
R25 39
R21 390
R22 560
R18 680
2N961 Q4
2N918 Q5
Q3 2N961
C15 5.6 pf
C16 .01μf
C17 .01μf
R26 1.2K
R24 220
R23 390
CR14 CD3319
R20 68
R19 1K 1%
R28 820
R38 56K
R34 27
-15V
C14 .01μf
1
C
3 TEST ENABLE f-1μs COUNT ENABLE
4 T-B COUNT ENABLE
5 STOP LINE
7 START LINE
8 MULTIPLE
K M-LOGIC
10 MC IN PUT
OUT PUT

INSTRUCTION MANUAL

MODEL 6120

FREQUENCY METER



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

February 1965

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

CONTENTS

		Page
SECTION 1 — INTRODUCTION		
1.1	General	1-1
1.2	Specifications	1-1
1.3	Applications	1-1
1.4	Accessories	1-3
SECTION 2 — OPERATION		
2.1	Applying Power	2-1
2.2	Controls and Connectors	2-1
2.3	Test	2-3
2.4	Operate Mode	2-4
2.5	Accuracy	2-4
SECTION 3 — CIRCUITS		
3.1	General	3-1
3.2	Logic Circuits	3-2
3.3	Input Circuit	3-3
3.4	Time Base Generator	3-5
3.5	Control	3-7
3.6	Recycle	3-12
3.7	Legend	3-16
3.8	Power Supply	3-17
3.9	Basic Circuits	3-19
SECTION 4 — SERVICING		
4.1	General	4-1
4.2	Adjustments	4-5
SECTION 5 — PARTS LIST		
MODIFICATIONS		

ILLUSTRATIONS

Figure		Page
1-1	Model 6120 Frequency Meter with Model 696 Basic Plug-In	1-1
1-2	Model 622 Plug-In	1-3
1-3	Model 607 Plug-In	1-3
2-1	Operating Controls and Connectors	2-1
2-2	Auxiliary Controls and Connectors	2-2
2-3	Operate Mode	2-4
2-4	Error Due to Gating Action	2-5
2-5	Error Due to Input Noise	2-5
2-6	Reducing Rise Time Reduces Error Due to Noise	2-6
3-1	Simplified Block Diagram	3-1
3-2	Typical Logic Circuit	3-2
3-3	Typical Logic — Alternate Configuration	3-2

continued. . .

ILLUSTRATIONS - continued

Figure		Page
3-4	F Logic — TEST Mode	3-3
3-5	Input Circuit Block Diagram	3-3
3-6	Voltage Discriminator Output in Relation to Input Voltage Excursion	3-4
3-7	Input Circuit — Idealized Waveforms	3-5
3-8	Time Base Block Diagram	3-5
3-9	Divider Input Waveforms in Relation to Divider Output Waveforms	3-6
3-10	Control Circuit Block Diagram	3-7
3-11	Control Circuit Timing	3-8
3-12	Gate Control — Ready	3-9
3-13	Gate Control — Counting	3-10
3-14	Gate Control — Data Storage	3-11
3-15	Recycle Sub-System	3-12
3-16	Recycle Timing	3-12
3-17	Recycle Functional Block Diagram	3-13
3-18	Recycle Rate Generator — "Off"	3-14
3-19	Recycle Rate Generator — "On"	3-15
3-20	Photoconductor Switching Circuit — Simplified	3-17
3-21	Legend Circuit — Simplified	3-18
3-22	EL Supply — Simplified	3-19
3-23	Gate Circuits - Typical	3-20
3-24	Typical Binary	3-21
3-25	Typical One-Shot Circuit	3-21
3-26	Typical Voltage Discriminator	3-22
4-1	Top Cover Removal	4-2
4-2	Bottom Cover	4-2
4-3A	Component Location — Top View	4-3
4-3B	Component Location — Bottom View	4-4
4-4	Power Supply Adjustments	4-5
4-5	Power Supply Test Points	4-6
4-6	Rear Panel View Showing Location of Crystal Adjust	4-6
4-7	Bottom View of Model 6120 Showing Multiplier Test Point	4-7
4-8	Top View of Model 6120 Showing Multiplier and Input Level Adjust	4-7

TABLES

Table		Page
1-1	Specifications	1-2
1-2	Plug-In Accessories	1-3
2-1	Operating Controls and Connectors	2-2
2-2	Auxiliary Controls and Connectors	2-3
2-3	Correct Count Indications	2-3
4-1	Test Equipment	4-1
4-2	Printed Circuit Board Identification	4-5

DIAGRAMS

Model 696 Plug-In Schematic	A415929
Model 6120 Block	D422808
Model 6120 Unit Logic Schematic	D422737
Model 6120 Count Schematic	D422785
25 Mc Amplifier Schematic	64C-6100-006
Printed Circuit Board	A414707
F Logic Schematic	C422421
Printed Circuit Board	A422376
Time Base Logic Schematic	C422424
Printed Circuit Board	A422422
1 Mc Oscillator & Shaper Schematic	C411996
Printed Circuit Board	A411676
1 - 10 Mc Multiplier Schematic	64B-6100-004
Printed Circuit Board	A412605
First Divider Schematic	C422000
Printed Circuit Board	C422002
Second Divider Schematic	C422001
Printed Circuit Board	C422003
Recycle Schematic	64D-6100-025
Printed Circuit Board	B411673
Control Schematic	64C-6100-014
Printed Circuit Board	A410903
Legend Schematic	D422433
Printed Circuit Board	B422431
Power Supply Schematic	64D-6100-023
EL Supply Printed Circuit Bd.	A412795
Regulator Printed Circuit Bd.	A412442

APPENDICES

Model 870 DCU Instruction Manual

Data Storage Unit Instruction Manual

Model 860 DCU Instruction Manual

Model 850 DCU Instruction Manual

SECTION 1
INTRODUCTION

1.1 GENERAL

The Beckman Model 6120 is the frequency-meter version of the 6100 Series of solid-state counting and timing instruments. Controls and functions not directly related to frequency measurements have been eliminated allowing frequencies to be checked directly — with very little effort required of the operator. The six-digit, in-line, electroluminescent display includes decimal point and legend.

1.2 SPECIFICATIONS

Specifications for the Model 6120 are given in Table 1-1.

1.3 APPLICATIONS

Many laboratory, field test, and production line requirements are satisfied with the Model 6120 Frequency Meter.

Various transducers such as photocells, magnetic pickups and switches are useful in translating physical phenomena into voltage changes. With appropriate transducers, this counter can measure characteristics of physical events relative to time. Listed below are a few of the many applications.

Tachometry.

Monitor AM, FM, and TV frequencies in both VHF and UHF.

Oscillator and crystal testing.

Telemetry and Radar beacon frequency checks.

Secondary frequency standard.

Other important applications include frequency checks of both transmitters and receivers used in mobile communications, and many other production and monitoring checks for VHF, UHF, and microwave devices.

Fig. 1-1 Model 6120 Frequency Meter with Model 696 Basic Plug-In

Table 1-1. Specifications

Input Characteristics	
Sensitivity	100 mv to 1 v rms.
Frequency Response	25 cps to 25 mc.
Coupling	AC only.
Resistance	20 k shunted by 40 pf.
Trigger Control	Internal adjustment ±1 volt.
External Reference Frequency	
Range	1 mc ±10%.
Level	1 v rms.
Impedance	1 k.
Stability	
Long Term	3 parts in 10^7 per week (after 72-hour operation).
Short Term	1 part in 10^8 per week (10 second average) after 1 hour operation.
Frequency Accuracy	±1 count ± oscillator stability.
Time Range Selection	10 μs to 1 second in decade steps.
Recycle Rate	Variable from 0.1 cps to 7 cps, or manually controlled.
Display	Six in-line digits displayed on electroluminescent panel. Automatic decimal point and legend.
Environmental	
Operating Temperature Range	-20°C to +65°C: at 200 mv input sensitivity or 100 mv sensitivity with amplifier retriggering. 0°C to +55°C: at 100 mv input sensitivity without retriggering.
Storage Temperature Range	-55°C to +75°C
Power Requirements	115 or 230 v ac ±10%, 50-60 cps, 100 watts.
Dimensions	5-1/4" high, 16-3/4" wide, 19" deep.
Weight	40 pounds.

1.4 ACCESSORIES

Table 1-2 lists the solid-state plug-in units available for use with the Model 6120 counter.

Table 1-2 Plug-in Accessories

Model 605A Prescaler	Extends the direct count frequency measuring range of the Model 6120 to 350 mc.
Model 605A with CA Option	The CA option increases the sensitivity of the Model 605A to 10 mv rms.
Model 607 1000 mc Heterodyne	Indirectly extends the frequency measuring range of the Model 6120 to cover the 25 to 1000 mc band.
Model 622 Mode Expander Preset	Permits the Model 6120 to be used in many counter-controller applications.
Model 651 Voltage-to-Frequency Converter	Produces an output frequency which is precisely proportional to a dc input voltage.

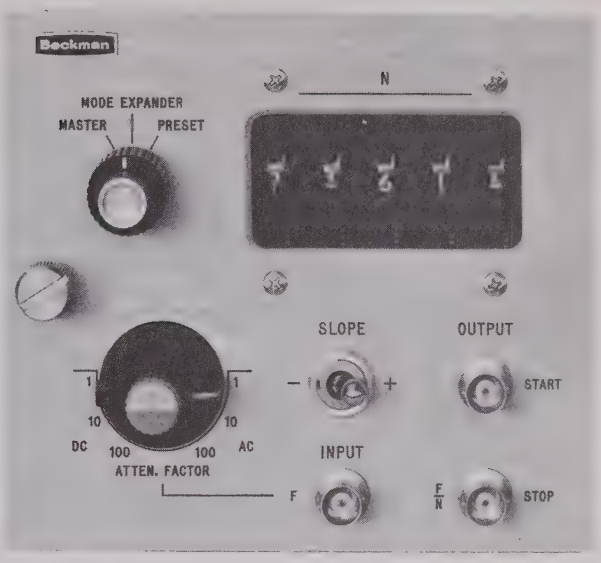


Fig. 1-2 Model 622 Plug-In

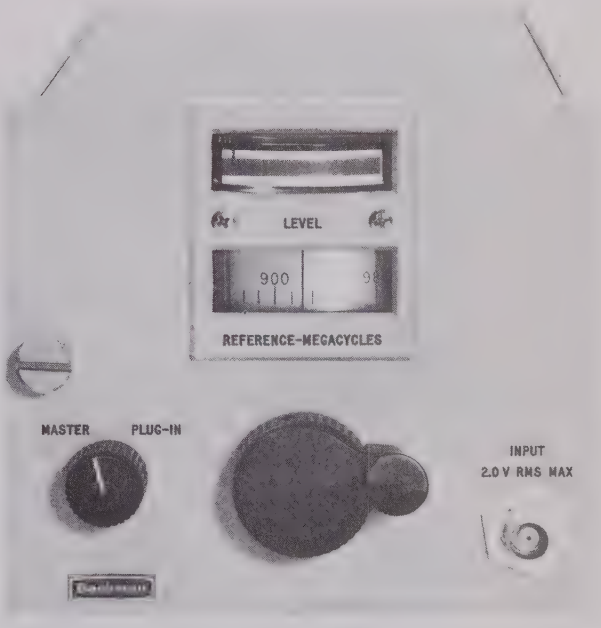


Fig. 1-3 Model 607 Plug-In

SECTION 2
OPERATION

NOTE

Do not remove the Model 696 Basic Plug-in unless other accessory plug-ins are used. Each plug-in completes circuits in the instrument that are essential for operation.

2.1 APPLYING POWER

The instrument is ready for use as it arrives from the factory. To energize the unit, plug the power cord into a source of 117 volts ac, 50-60 cycles. The crystal oscillator and oven circuits energize immediately. Turn the POWER switch on to energize all circuits in the instrument. The oscillator will reach a stability of 3 parts in 10^7 per week after 72 hours of continuous operation. Therefore, if the instrument is to be used intermittently, leave the power cord connected to avoid waiting for crystal warm-up.

2.2 CONTROLS AND CONNECTORS

2.2.1 Operating Controls and Connectors

The operating controls and connectors are on the front panel as shown in Figure 2-1. Table 2-1 explains their function.

2.2.2 Auxiliary Controls and Connectors

Unless otherwise noted, auxiliary controls and connectors are on the rear panel, as shown in Figure 2-2. Table 2-2 explains their function.

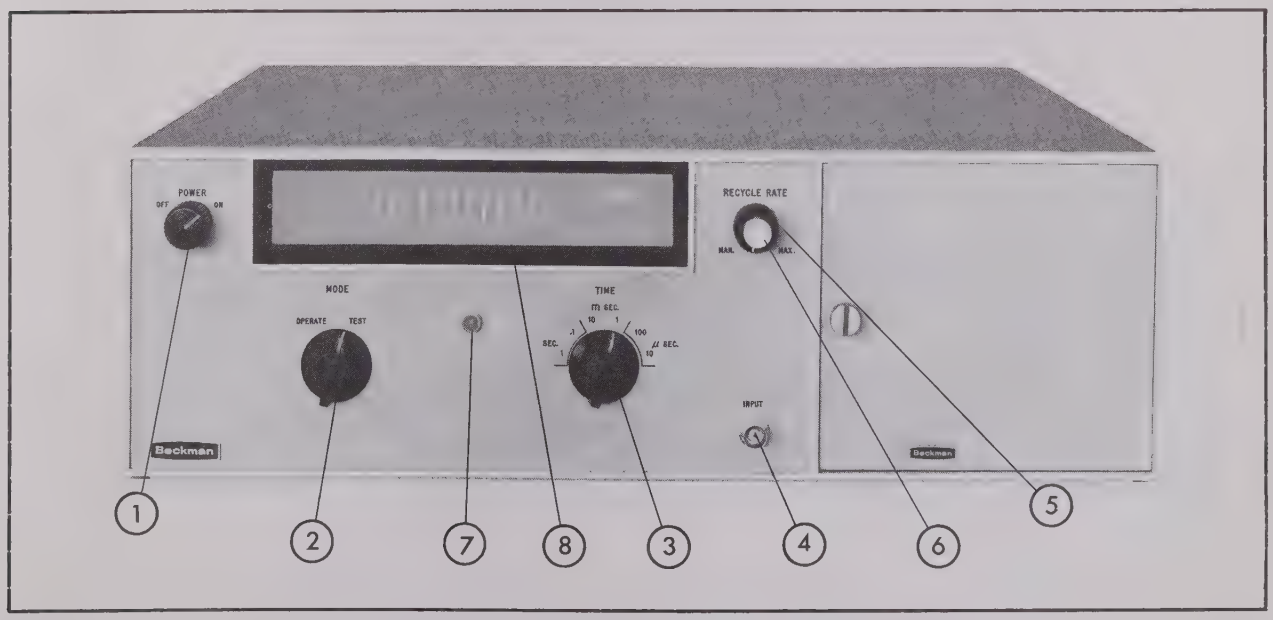


Fig. 2-1 Operating Controls and Connectors

Table 2-1 Operating Controls and Connectors

Control or Connector	Function
1) POWER Switch	Energizes the instrument when turned to ON.
2) MODE Selector	Interconnects logic blocks to perform measurements indicated.
3) TIME Selector	Selects gate time for OPERATE and TEST.
4) INPUT Connector	For signal inputs.
5) RECYCLE RATE Control	Controls rate at which new data is sampled. MAX: Recycle is at maximum rate. MAN: Recycle is controlled by pressing RESET pushbutton.
6) RESET Pushbutton	Instrument resets and accumulates a new count.
7) GATE OPEN Light	Light is on when count gate is open. Provides additional indication of counter recycle.
8) EL Display Panel	Displays measurement, units, and decimal point.

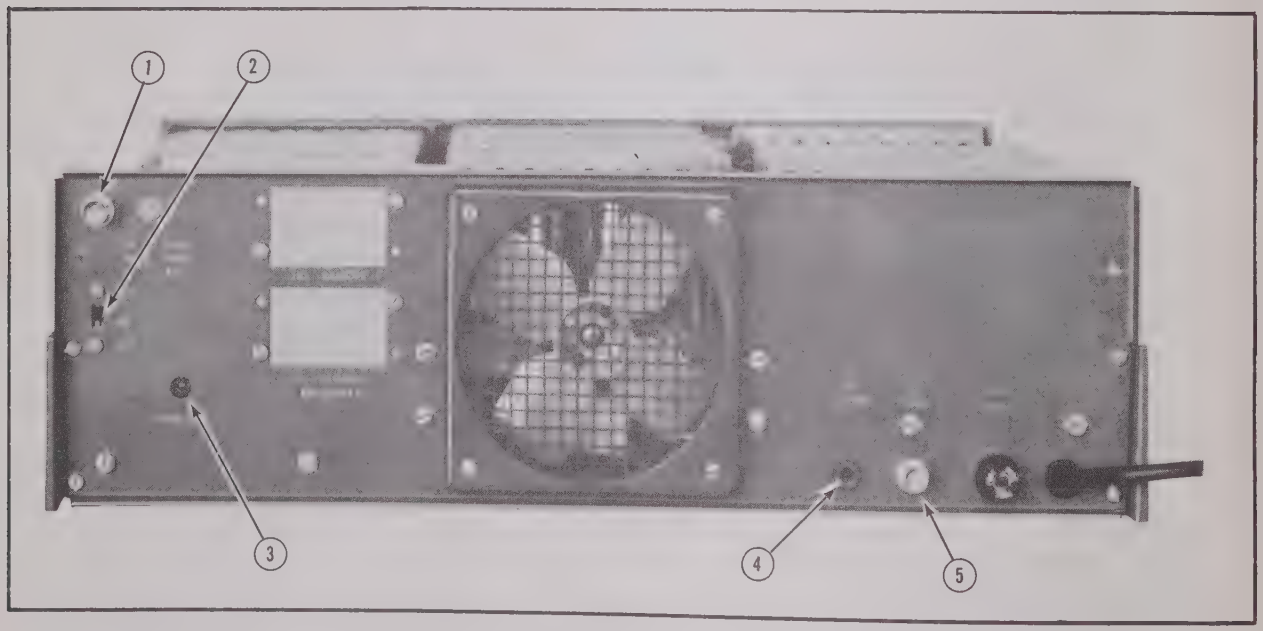


Fig. 2-2 Auxiliary Controls and Connectors

Table 2-2 Auxiliary Controls and Connectors

Control or Connector	Function
1) FREQ Connector (J4)	Performs either of two functions depending on position of S6 (EXT-INT). EXT: An external signal can be introduced to substitute for oscillator. Signal must be between 0.9 mc and 1.1 mc and capable of producing 1 volt rms across 1 k ohm. INT: Internal oscillator can be monitored.
2) INT-EXT Switch (S6)	EXT: Disconnects oscillator output. Allows external time base to be used. INT: Internal oscillator is used as the time base, and can be monitored at FREQ connector.
3) FREQ ADJ (C1)	For adjustment of oscillator frequency. (See Section 4.)
4) SCOPE Jack (J5)	Used for monitoring the state of the signal gate. Gate closed: Voltage at ground potential. Gate open: Voltage at -10 volts with respect to ground.
5) TIME Connector (J3)	Makes time base generator available for external use. The 4 volt, 0.1 μs positive output pulses are accurately spaced at intervals selected by TIME selector. Output impedance is 1 k ohm.

2.3 TEST

The TEST position of the MODE selector provides a quick, uncomplicated method of checking the instrument for proper operation. TEST checks time base, recycle, gate control, decimal counting units (DCU's), and data storage units (DSU's).

To test the instrument follow this procedure:

1) Set POWER switch to ON.

2) RECYCLE RATE control: Retard recycle time to approximately one reading per second for best observation.

3) Turn MODE selector to TEST.

4) Turn TIME selector to each time position beginning with 10 microseconds. Table 2-3 shows correct count indications.

Table 2-3 Correct Count Indications

TIME Setting	Correct Count*
10 μs	00010.0
0.1 ms	0010.00
1 ms	010.000
10 ms	10.0000
0.1 ms	0.00000
1 sec.	.000000

*Reading may vary ±1 count due to normal gating error.

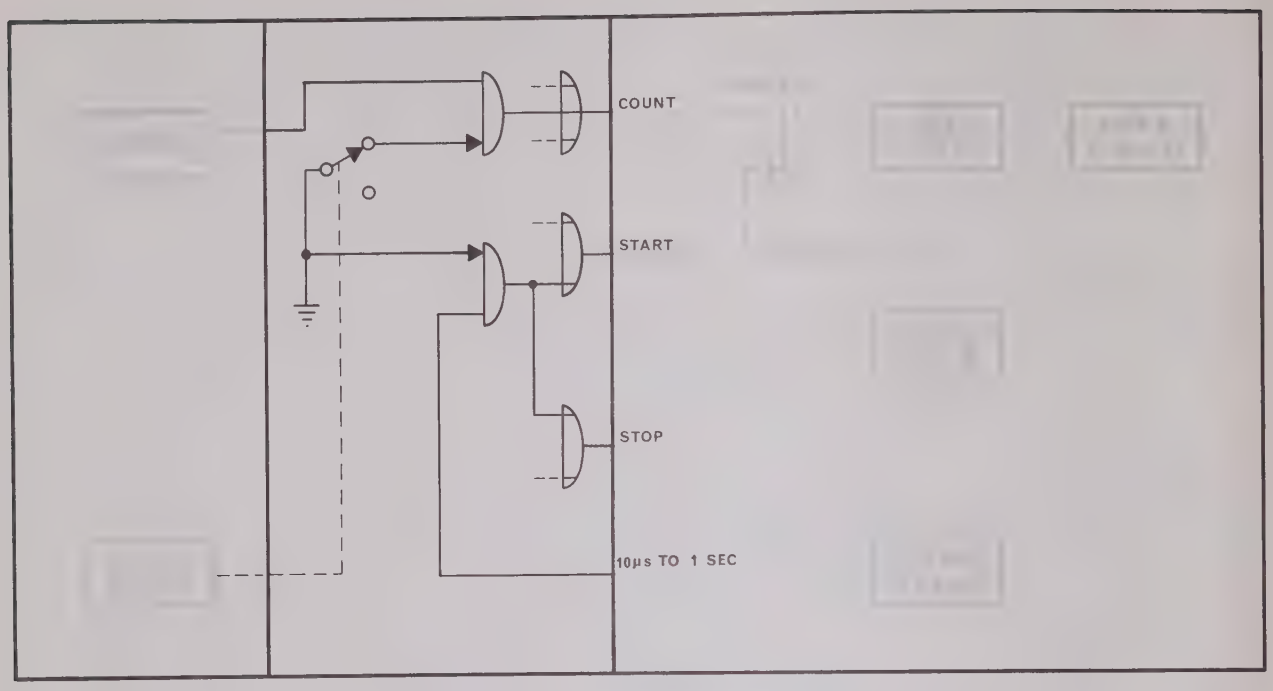


Fig. 2-3 OPERATE Mode

2.4 OPERATE MODE

In OPERATE mode, the instrument counts events during a time base interval selectable from 10 microseconds to 1 second. Logic for OPERATE is shown in Figure 2-3.

2.4.1 Procedure

1) Turn POWER switch to ON.

2) Connect input signal to INPUT; adjust trigger control if necessary (Section 4.2.4).

3) Turn MODE selector to OPERATE.

4) Set TIME selector to the desired timing interval. A longer time base increases the number of digits displayed, thus increasing measurement accuracy.

5) Adjust RECYCLE RATE control for a convenient reading or recording rate.

6) Readout displays count, measurement unit, and decimal point.

2.5 ACCURACY

Accuracy of a measurement depends on the sum of errors contributed from four sources: the gating action, the internal time standard, the input signal, and the resolution of the instrument.

2.5.1 Error Due to Gating Action

Figure 2-4 shows how gating action may cause the count indication to be in error by as much as ±1 count. If the gate opens just before a count

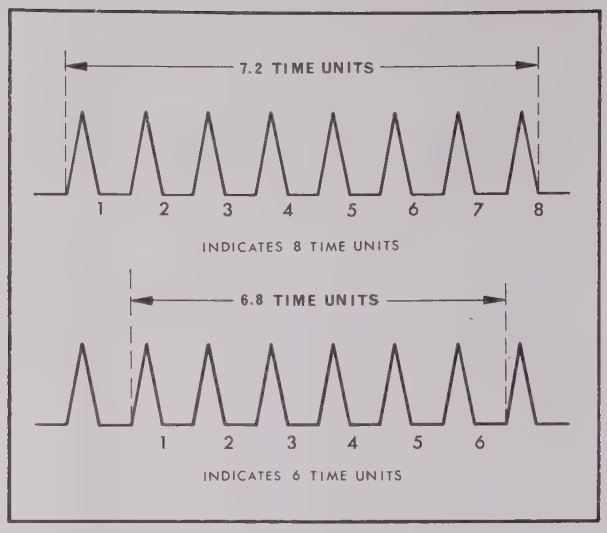


Fig. 2-4 Error Due to Gating Action

pulse and closes immediately after another, the indication may be one time unit high. But if the gate opens just after a pulse and closes just before another, the indication may be one time unit low. In no case will the error be greater than one time unit.

2.5.2 Error Due to Internal Time Standard

The internal time standard is a crystal oscillator housed in a thermostatically controlled chamber. The oscillator is subject to deviations from an absolute standard, and may change frequency during the interval between two calibrations. Once set, the oscillator will not vary more than three parts in 10^7 per week, which means that measurements made within the same week can be compared with a maximum error of 0.00003 percent. If absolute (as distinguished from comparative) time is important, the oscillator may be periodically adjusted to correspond with the standard frequencies broadcast from the National Bureau of Standards radio stations, WWV or WWVH.

2.5.3 Error Due to Non-Representative Input Signal

The instrument begins timing at the instant the input excursion passes through the trigger voltage level. If the input contains "noise" (where noise is defined as any voltage variation not representative of the event being timed), the noise may cause the input voltage to reach the trigger level too soon. Figure 2-5 shows the effect of noise, if noise is a higher frequency imposed on the ideal input signal.

The best way to avoid error is to use a noise-free signal of the largest acceptable amplitude. A fast rise time will reduce the error greatly. Figure 2-6 shows that, given two voltage excursions with equal noise, the one with the faster rise time will cause less error.

The error due to noise can be calculated with the following formula:

$$t = \frac{E_n}{S}, \text{ where}$$

t = maximum possible error in seconds

E_n = peak-to-peak noise in volts

S = Slope (volts per second) of ideal signal at trigger point.

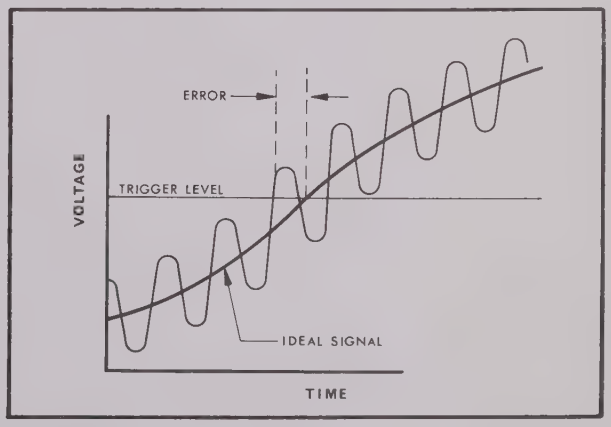


Fig. 2-5 Error Due to Input Noise

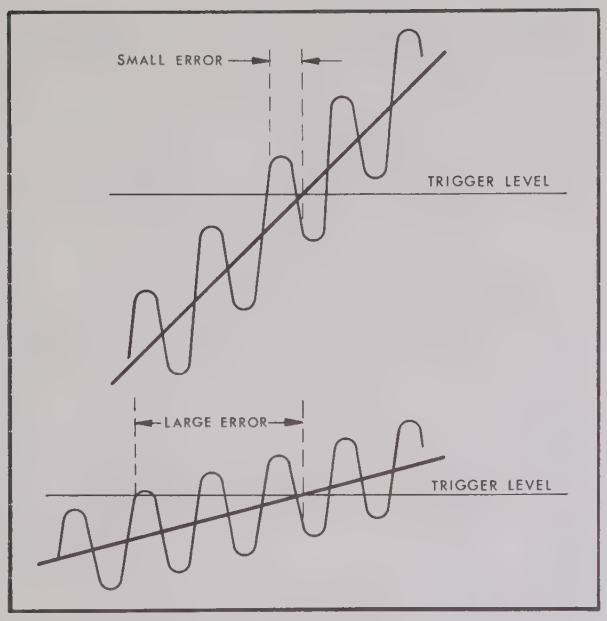


Fig. 2-6 Reducing Rise Time Reduces Error Due to Noise

2.5.4 Resolution Error

The minimum time that must elapse between events if both are to be counted is termed the resolution time of the instrument. Model 6120 has a resolution time of better than 0.04 microseconds.

Resolution error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuits may also cause a third event to fail to register.

SECTION 3
CIRCUITS

3.1 GENERAL

This section describes the operating theory of the Model 6120. As shown in Figure 3-1, Model 6120 consists of a time base generator (Section 3.4), one input circuit (Section 3.3), a signal gate and control circuit (Section 3.5), a recycle circuit (Section 3.6), a chain of decimal counting units (DCU's), and data storage units (DSU's) with an electroluminescent (EL) display. These major circuits are interconnected with logic gates (Section 3.2) which are controlled by the TIME and MODE selectors.

The power supplies are described in Section 3.8, and the Legend in Section 3.7. Basic circuits are covered in Section 3.9.

Frequency measurements are made by comparing the unknown input signal with an internal time base of known accuracy. When making a frequency measurement the signal gate opens and closes at a rate determined by the setting of the TIME selector. While the gate is open, pulses representing the input frequency are fed from the input circuit through the gate to the count DCU's. The accumulated count in the DCU's transfers to the DSU's at the end of a counting period and is displayed on the EL panel.

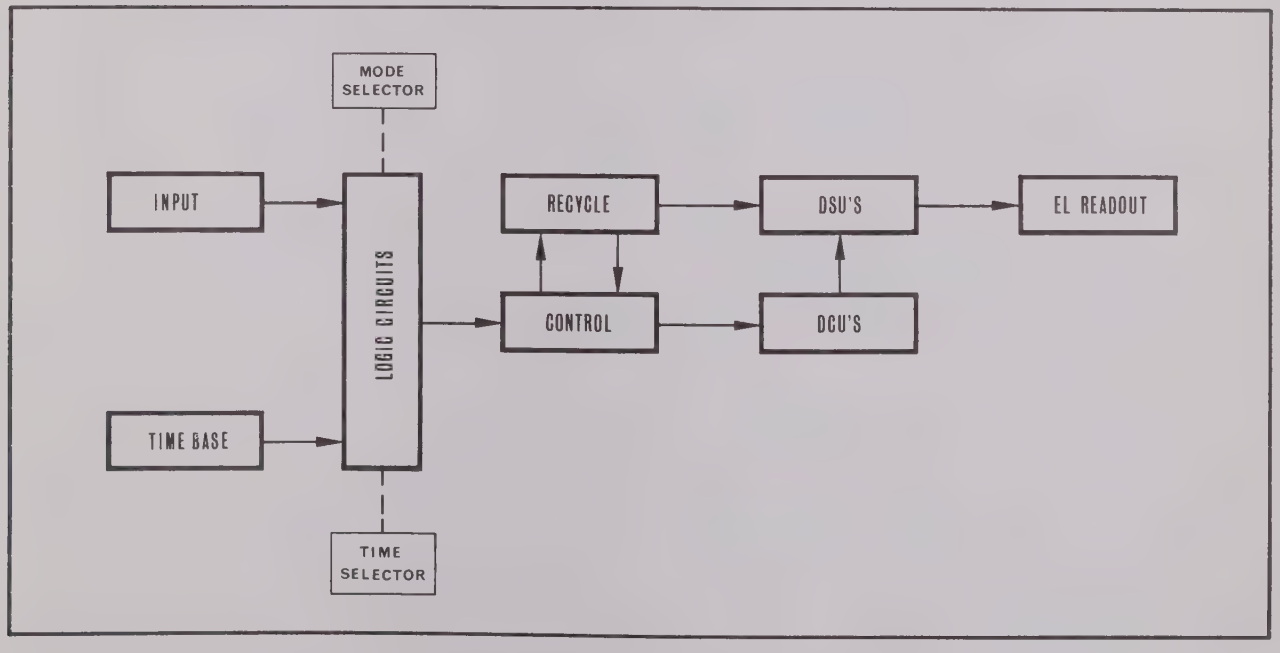


Fig. 3-1 Simplified Block Diagram

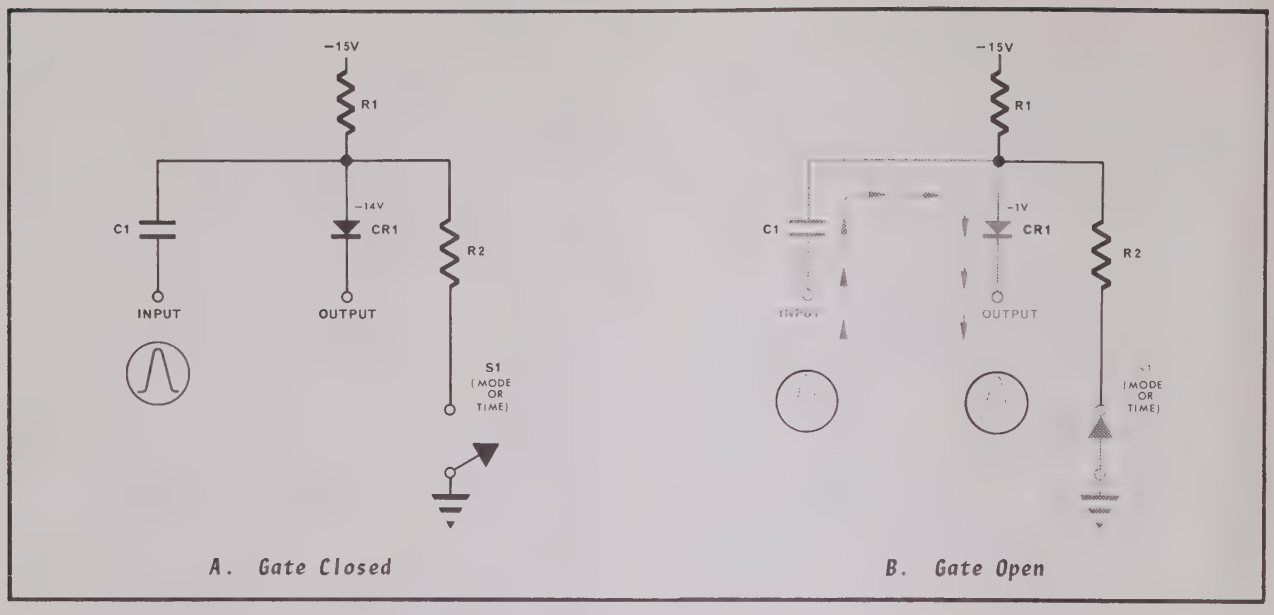


Fig. 3-2 Typical Logic Circuit

3.2 LOGIC CIRCUITS

Logic circuits switch and interconnect signal paths between major sections to perform the measurement indicated on the front panel. The logic circuits consist of diode AND gates which have their bias controlled by the TIME, MODE, and SLOPE controls. When a diode is reverse-biased, the gate is closed. Conversely, if a diode is forward-biased, the gate is open. Figures 3-2A and 3-2B, respectively, show a typical logic gate in the closed and open states.

As shown in Figure 3-2A, positive pulses at C1 have insufficient amplitude to overcome the reverse bias on diode CR1, and there is no output. In Figure 3-2B, S1 removes the reverse bias by effectively clamping the junction of R1 and CR1 to near ground potential. Positive pulses at C1 then pass through CR1 to the output.

Another configuration of the logic circuit is shown in Figure 3-3. In this circuit, CR2 replaces R2, but operation is identical to the circuits shown in Figures 3-2A and 3-2B.

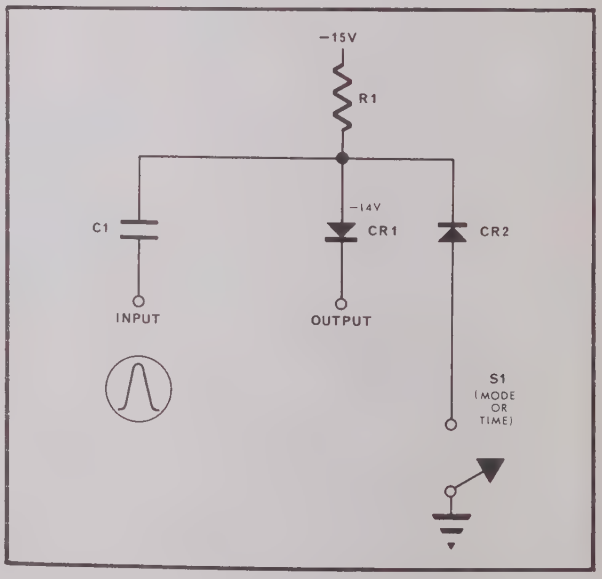


Fig. 3-3 Typical Logic -- Alternate Configuration

3.2.1 "F" Logic

The MODE selector controls the diode gates in the "F" Logic. Therefore, main mode switching is accomplished in this circuit. Figure 3-4 shows "F" Logic for the TEST mode.

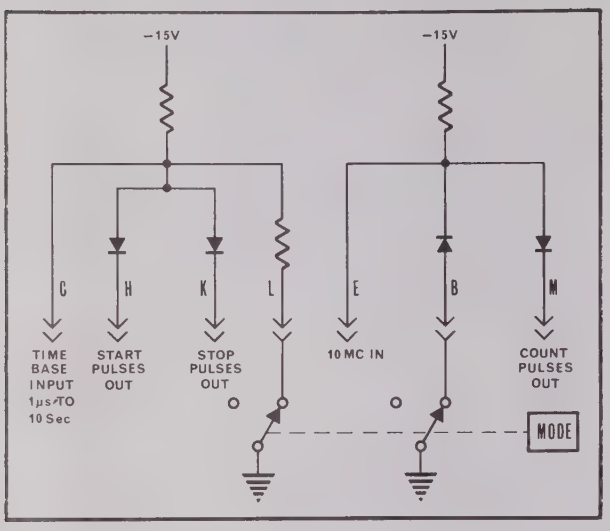


Fig. 3-4 F Logic -- TEST Mode

3.2.2 Time Base Logic

Controlled by the TIME selector, the time base logic selects the desired time base output from the frequency dividers. The selected time base is fed through shaper stage Q1, Q2 for amplification and pulse shaping. The shaper is described in detail under "Basic Circuits", Section 3.9. Operation of the time base logic is discussed further in Section 3.4.

3.3 INPUT CIRCUIT

As shown in Figure 3-5, the input circuit comprises three major sections: amplifier, voltage discriminator (Schmitt trigger circuit), and a pulse amplifier.

The function of the input circuit is to generate pulses of uniform size and shape which represent the input signal. Each time the input signal

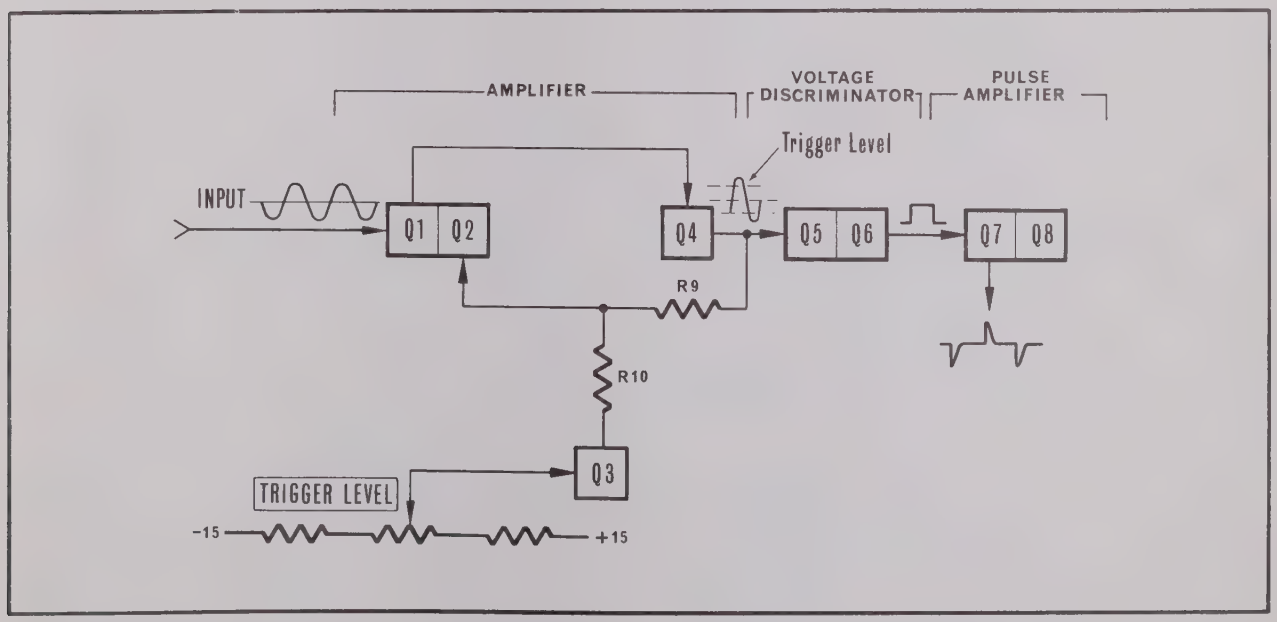


Fig. 3-5 Input Circuit Block Diagram

passes through a selected voltage level, the input circuit produces an output pulse which is independent of input waveform shape.

In the OPERATE mode output pulses are counted during a precise time base interval.

3.3.1 Amplifier

Amplification of the input signal occurs in transistor stages Q1, Q2, and Q4. Amplifier gain is determined primarily by the amount of feedback from transistor Q4 to Q2, and this level depends on the ratio of R9 to R10.

The dc level at the input of the voltage discriminator is determined by transistor Q3 which is controlled by the TRIGGER LEVEL control. This control is able to shift the ac signal at the base of transistor Q5 ±1 volt, thereby allowing a selected portion of the signal to pass through the hysteresis range of the voltage discriminator.

3.3.2 Trigger Voltage Level

As shown in Figure 3-5, the TRIGGER LEVEL control is an integral part of the amplifier, and sets the trigger voltage level of the discriminator circuit. An output pulse is generated each time the input signal passes through the hysteresis range of the discriminator. (Hysteresis is a small fixed voltage range centered around a fixed dc level at the discriminator input.) Figure 3-6 shows the output of the discriminator in relation to input voltage excursions through the hysteresis range.

The amplifier output (discriminator input) can be shifted by the TRIGGER LEVEL control in a positive or negative direction, thus allowing the operator to select a particular point on the waveform to trigger the discriminator. Triggering will occur providing that the voltage

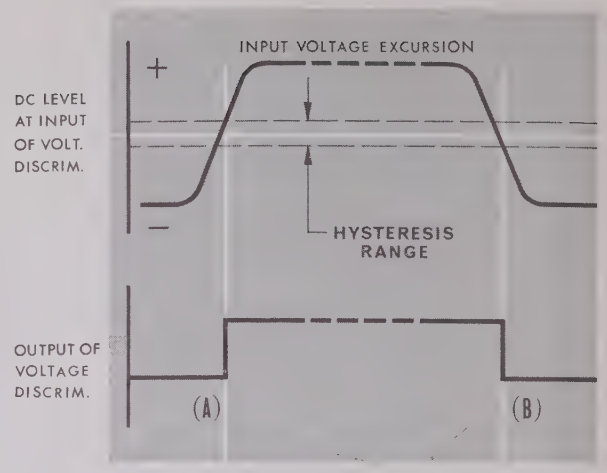


Fig. 3-6 Voltage Discriminator Output in Relation to Input Voltage Excursion

change has sufficient amplitude to pass through both limits of the hysteresis range.

3.3.3 Voltage Discriminator

The voltage discriminator (Q5, Q6) produces a square-wave output which is independent of the input waveform shape. Triggering of the circuit occurs when the signal at the base of Q6 passes through the hysteresis range of the voltage discriminator. The circuit returns to its original state when the input signal passes back through the hysteresis range. The output square wave is fed to pulse amplifiers Q7 and Q8.

Detailed operating principles of the voltage discriminator appear in Section 3.9.

3.3.4 Pulse Amplifier

The purpose of the pulse amplifier is to amplify and shape the output of the voltage discriminator. The output pulse available at the collector of Q7 is used to drive the F Logic circuit. Idealized waveforms of the input circuit are shown in Figure 3-7.

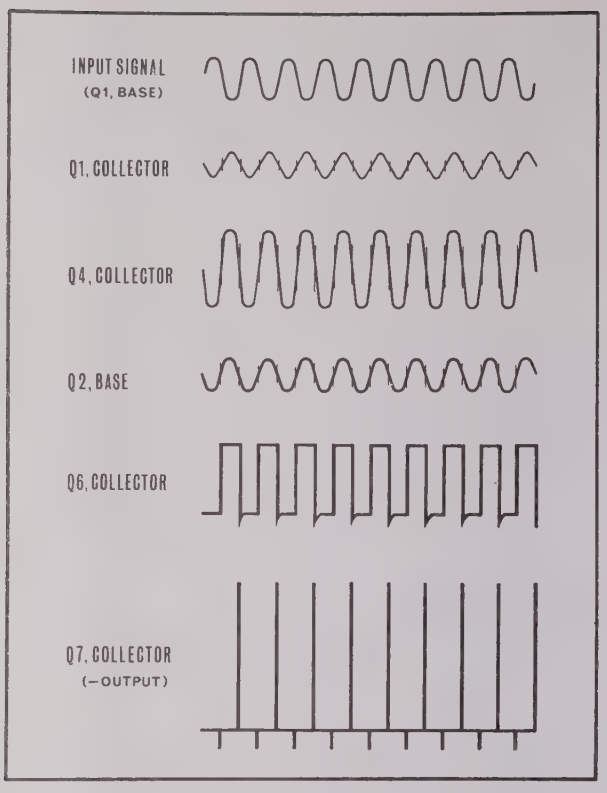


Fig. 3-7 Input Circuit -- Idealized Waveforms

3.4 TIME BASE GENERATOR

The time base generator consists of the 1 mc precision oscillator, 10 mc multiplier, frequency divider chain (1st and 2nd Dividers), and time base logic. See Figure 3-8, Time Base Block Diagram.

In OPERATE mode, the precise frequencies produced by the time base generator are used as control (start-stop) signals. The TIME selector setting determines which of the precise frequencies (10 microseconds to 1 second in decade steps) will be used. In TEST mode, the 10 mc output is counted, the time base being controlled by the TIME selector setting.

3.4.1 Oscillator

The oscillator comprises a 1 mc crystal (located external of the oscillator board) and transistor Q1. Oscillator frequency is adjusted with capacitor C1. The 1 mc output signal is coupled through C9 to buffer stage Q2.

The output of transistor Q2 is coupled to the shaper stage consisting of transistors Q3 and Q4. The shaper produces positive pulses which are routed to the frequency dividers and the 1-10 mc multiplier.

An external signal can be substituted for the oscillator by switching S6 to EXT (external) and applying the external reference signal to connector J4.

3.4.2 1 - 10 Mc Multiplier

The 1 mc signal from the oscillator circuit drives multiplier stage Q1. The collector circuit of Q1 is tuned to 10 mc with inductor L1. The output is taken from the junction of C7 and C8, and drives the count gate circuit. Another output is available across L2 and is terminated at J7 for use with plug-in accessories.

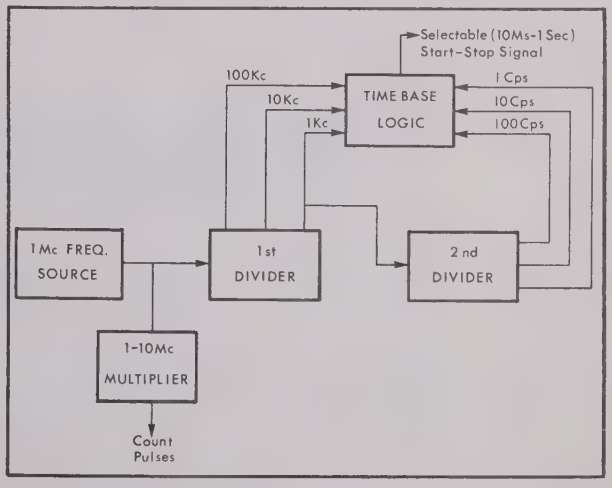


Fig. 3-8 Time Base Block Diagram

3.4.3 1st and 2nd Dividers

As shown in Figure 3-8, the 1st Divider, driven by the 1 mc oscillator, produces output frequencies of 100 kc, 10 kc, and 1 kc. The 2nd Divider, driven by the 1 kc output of the 1st Divider, produces output frequencies of 100 cps, 10 cps, and 1 cps. The operation of each divider state in the 1st and 2nd Divider is identical.

3.4.3.1 Frequency Divider

The following circuit description refers to the 100 kc divider located on the 1st Divider Schematic Diagram.

Transistors Q3 and Q4 comprise a binary circuit and transistors Q1 and Q2 comprise a one-shot circuit. Detailed operation of each circuit is given in Section 3.9; therefore, the following explanation describes the frequency divider operation only.

Initially (quiescent state) the binary is in one of two stable states: Q3 on Q4 off, or Q3 off Q4 on. Proper operation results regardless of the state of the binary. For purposes of explanation assume the following stable state: Q3 off Q4 on. In the one-shot circuit, transistors Q1 and Q2 are conducting in the quiescent state. The ground potential at the collector of Q1 forward-biases diodes CR2 and CR4.

At time 1, as shown in Figure 3-9, a positive input pulse from the 1 mc source coupled through C3 and CR4 triggers the binary to the active state: Q3 on Q4 off. The same pulse coupled through C2 and CR2 takes Q1 out of conduction. As Q1 turns off, the voltage at its collector drops to -15 volts. Diodes CR2, CR3, and CR4 are reverse-biased by the -15 volts at the collector of Q1. Transistor Q1 remains cut off for approximately 5 microseconds. During this time (times 2 through 5) pulses from the 1 mc source are blocked by diodes CR4 and CR3 and the binary remains in the active state. After time 5, one-shot action takes Q1 out of cut off and into saturation. Diodes CR2 and CR4 are again forward-biased as the voltage at the collector of Q1

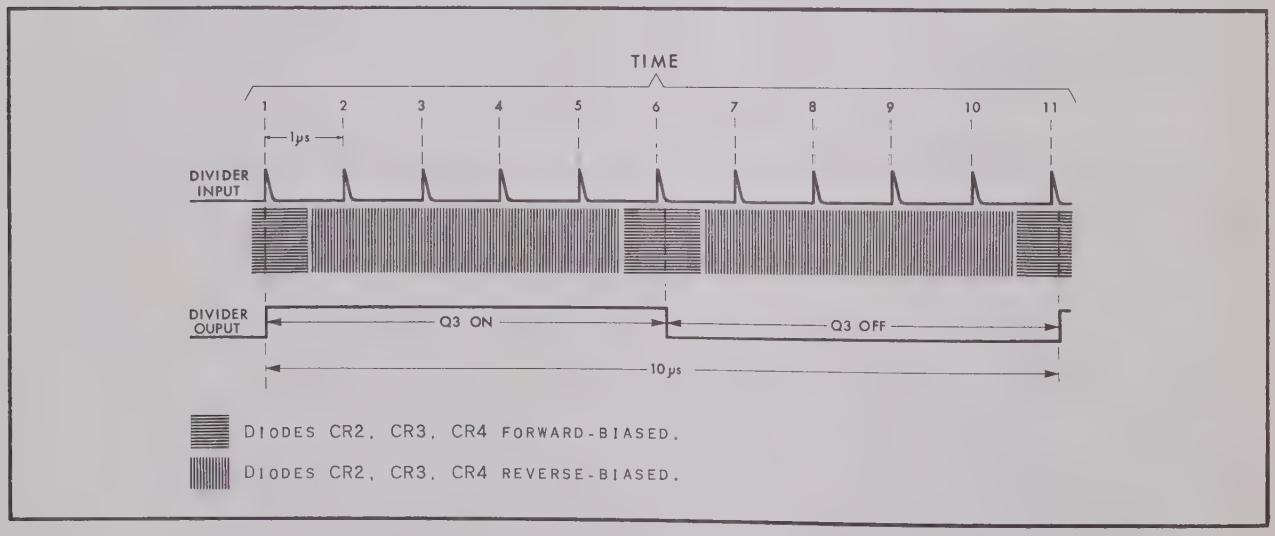


Fig. 3-9 Divider Input Waveforms in Relation to Divider Output Waveforms for a Period of 10 Microseconds. Shaded Areas Represent the Bias on Diodes CR2, CR3, and CR4 During Times Indicated

returns to ground potential. At time 6 the binary and the one-shot are again triggered and the entire process described above is repeated as shown in times 6 through 11; except that, in times 6 through 11 the binary is in the reverse state, Q3 off Q4 on.

3.5 CONTROL

The control section regulates the flow of pulses from other major sections (inputs X and Y, time base, etc.) to the count DCU's. This section consists of the start and control binaries, the signal gate (gate control and gate amplifier), and the gate shaper. Section 3.9 describes the operation of the binary and shaper in detail, since they are common to other sections in the instrument.

Briefly, the control section functions as follows (see Figure 3-10): upon application of a "start" pulse, the start and control binaries "flip", allowing the signal gate to open. While the signal gate is open, "count" pulses pass through the gate to be totalled by the count DCU's. The DCU's continue to register counts until a stop pulse is applied to the control binary which flips, closing the signal gate. The accumulated count in the DCU's transfers to data storage (DSU's), and is displayed on the EL panel. The method used to transfer information from the DCU's to the DSU's is described in Section 3.6 (Recycle).

Figure 3-11 shows the timing of the control section. Use the timing diagram with Figures 3-12, 3-13, and 3-14, which show the circuit conditions during "ready", "counting", and "data storage" times, respectively.

3.5.1 Ready Time

Ready time is defined as the time when the control section is prepared to accept a start pulse to begin a timing period. Start and control binaries are in the states shown in Figure 3-13 and the signal gate is closed.

3.5.2 Counting Time

Counting time is defined as the interval between a start pulse and a stop pulse, during which time the signal gate is open. See Figure 3-13.

3.5.3 Data Storage Time

Data storage time is defined as the interval between a stop pulse plus 10 microseconds clear and set time to the next stop pulse. See Figure 3-14.

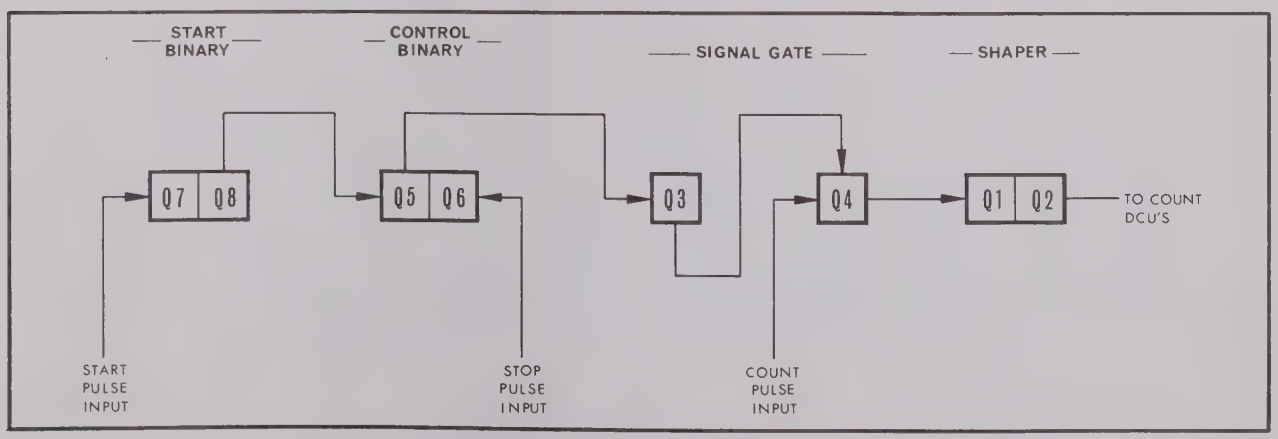


Fig. 3-10 Control Circuit Block Diagram

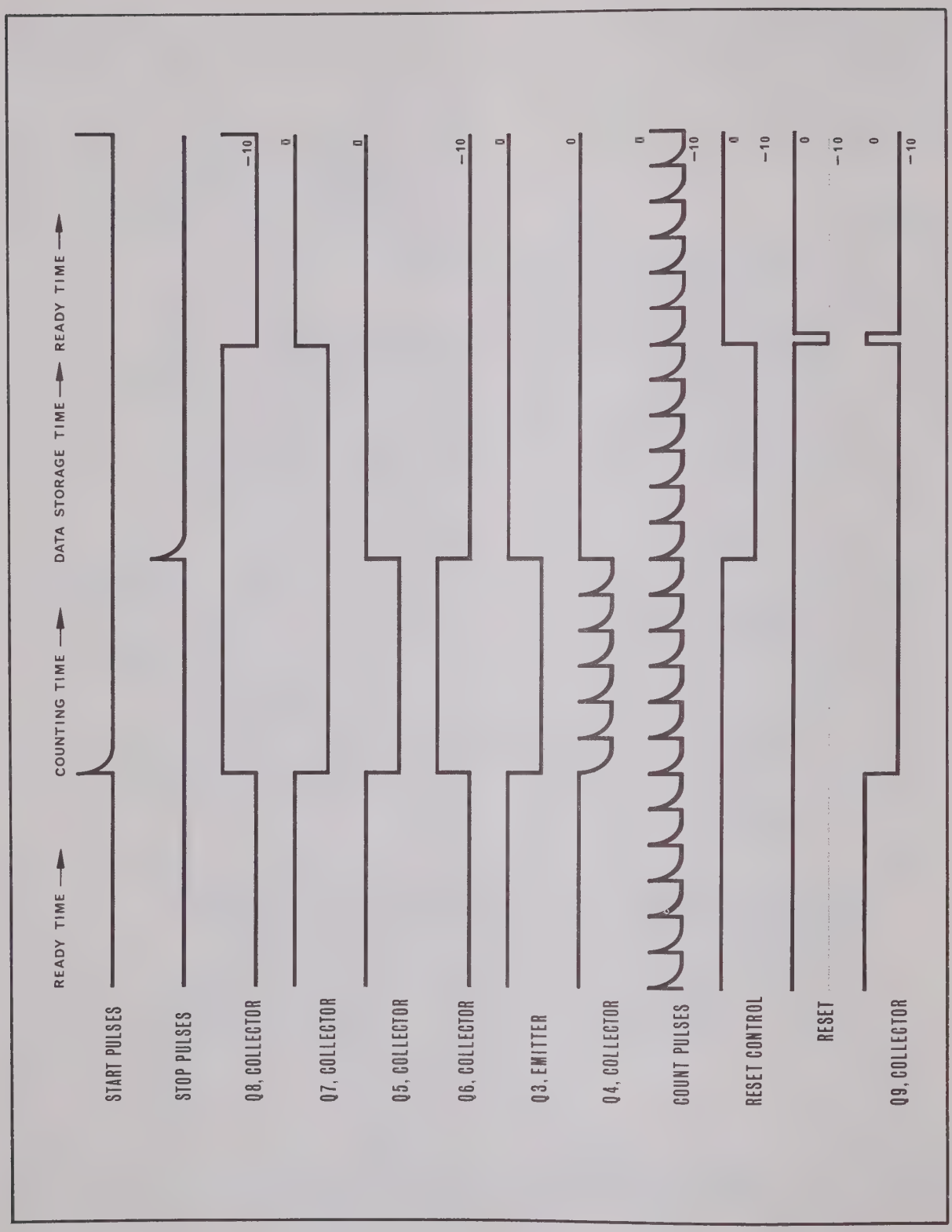
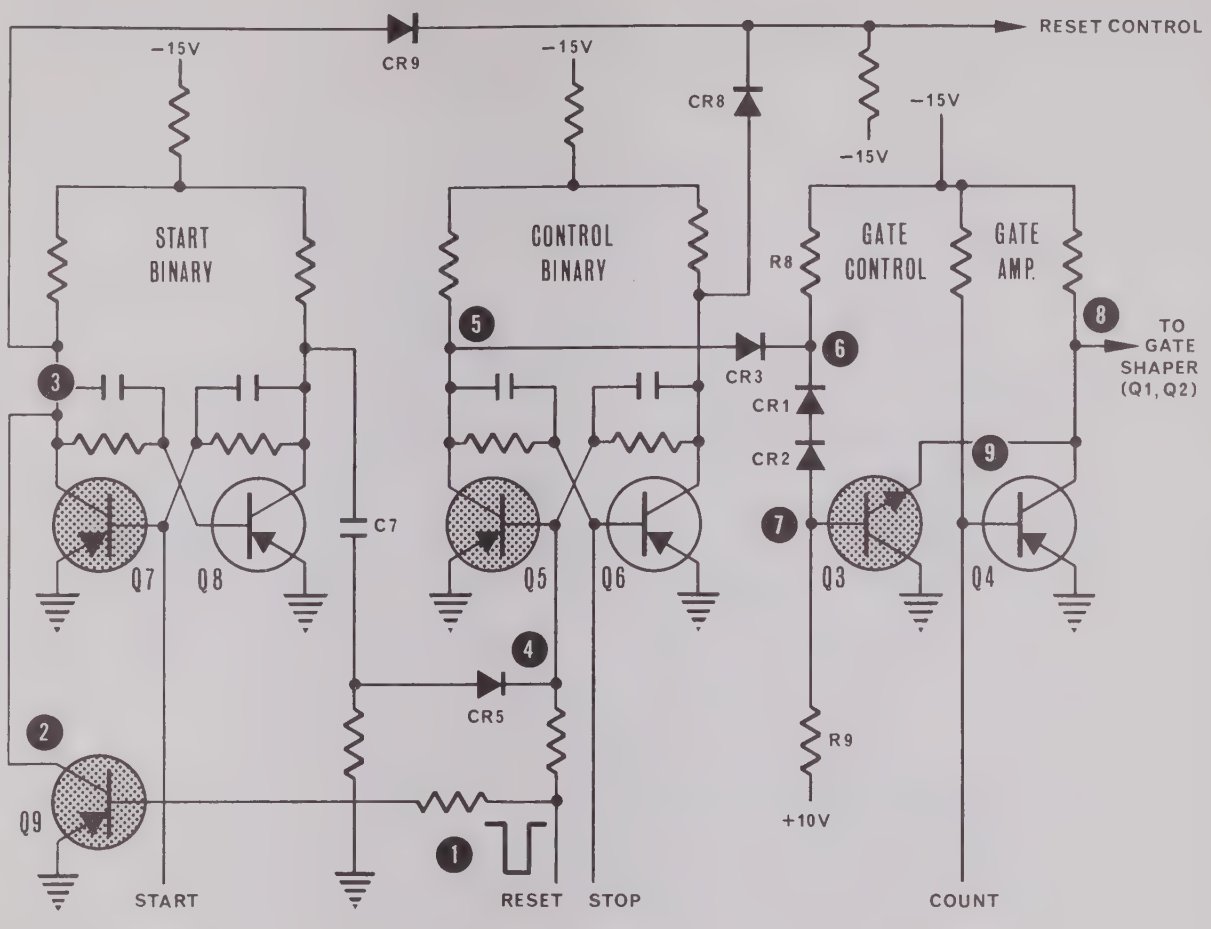


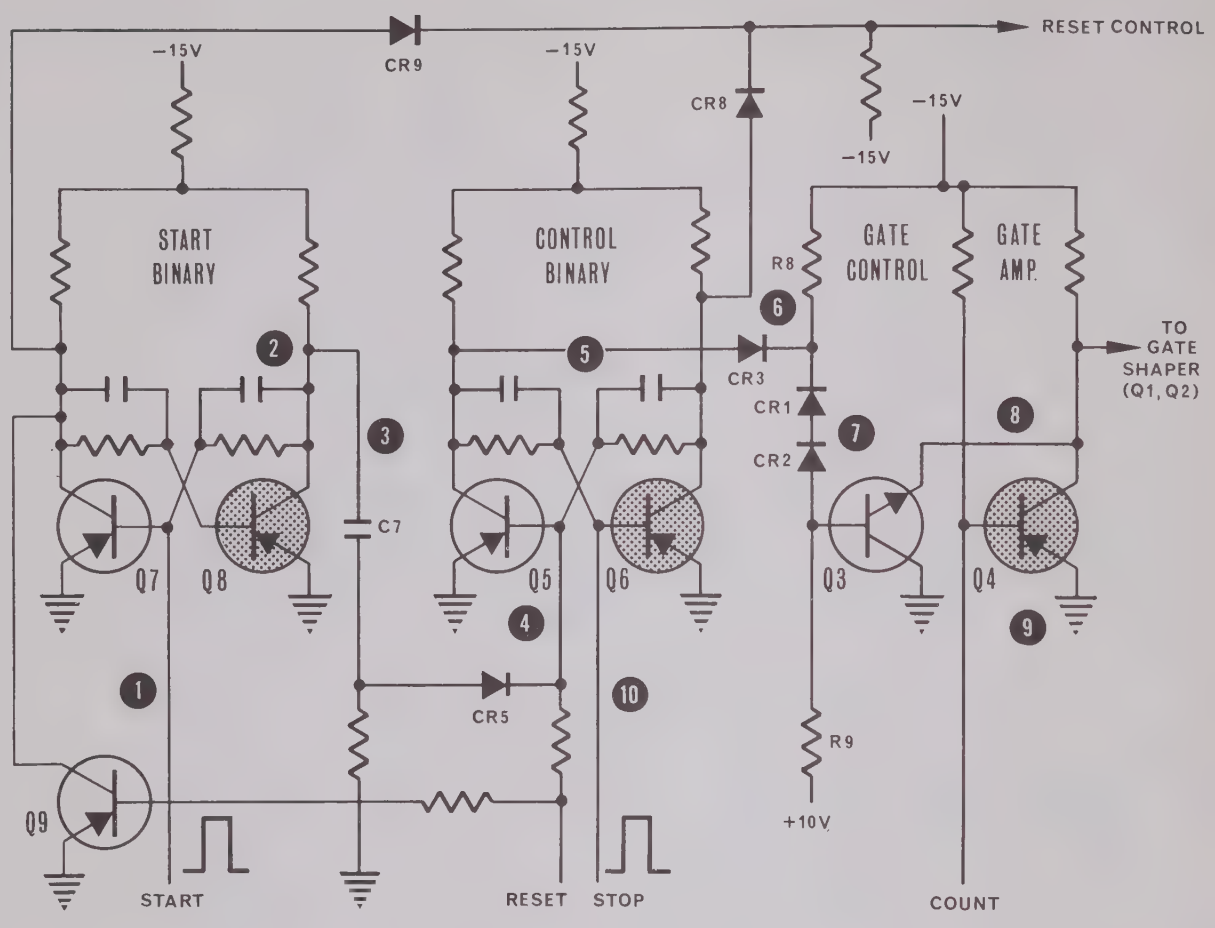
Fig. 3-11 Control Circuit Timing



Indicates an "on" (saturated) transistor.

1. Ready Time begins immediately after a reset pulse.
2. Reset pulse turns Q9 on for 10 μs.
3. Positive pulse couples to Q8 base.
4. Reset pulse ensures that Q5 is on, Q6 off.
5. Q5 collector is near ground potential, forward biasing CR3.
6. Forward-biased CR3 clamps the bottom of R8 to ground.
7. Q3 base becomes positive, Q3 turns on.
8. Q3 emitter rises toward ground potential, clamps Q4 collector at ground.
9. Signals (count pulses) at Q4 base cannot affect the collector circuit; therefore, the gate is closed.

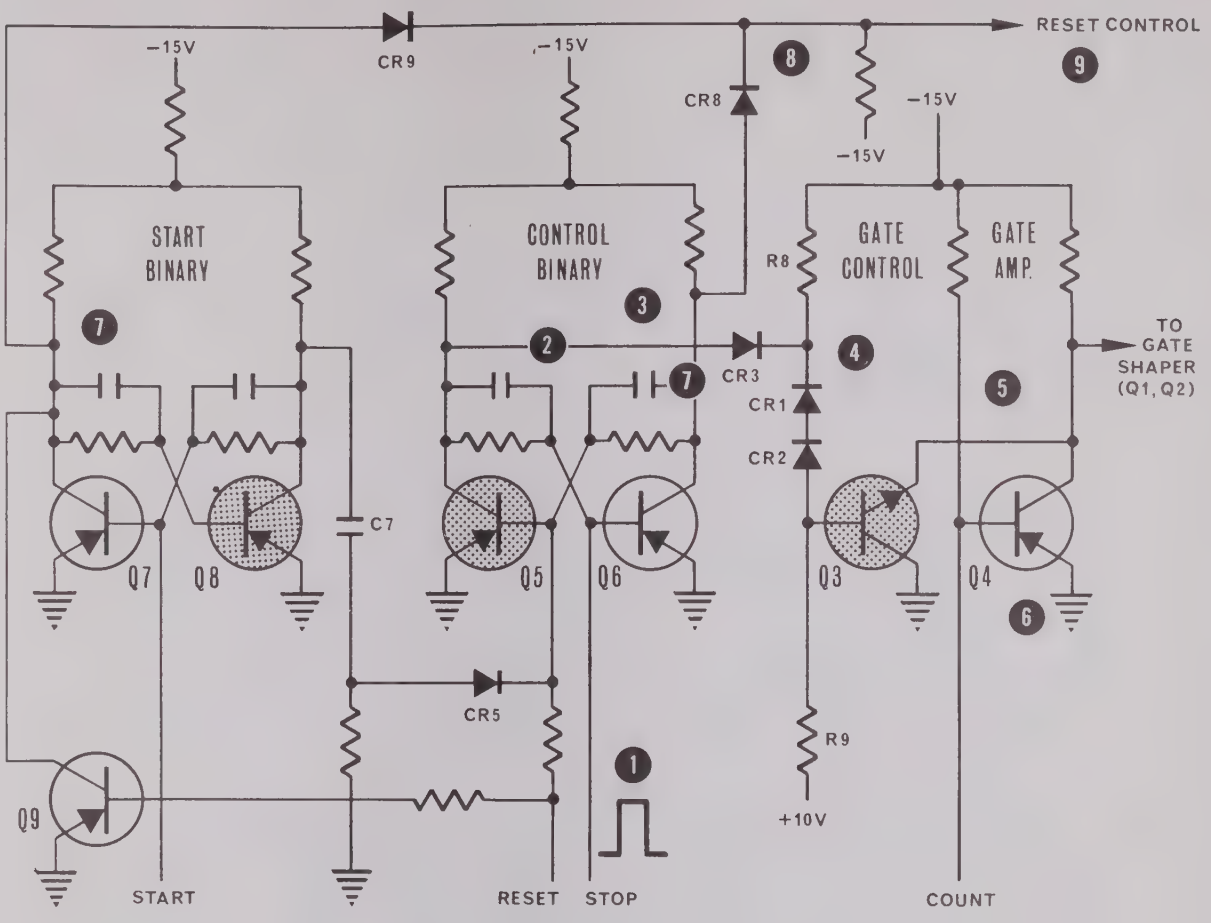
Fig. 3-12 Gate Control -- Ready



Indicates an "on" (saturated) transistor.

1. Counting Time begins when a start pulse reaches Q7 base.
2. Q7 turns off, Q8 turns on.
3. Q8 collector rises toward ground potential.
4. Positive transient couples to Q5 base.
5. Q5 turns off, Q6 turns on.
6. Q5 collector goes negative, reverse-biases CR3.
7. R8 is unclamped from ground and Q3 base goes negative.
8. Q3 turns off, unclamping Q4 collector.
9. Count pulses pass through Q4 to count DCU's.
10. A stop pulse ends counting time.

Fig. 3-13 Gate Control -- Counting



Indicates an "on" (saturated) transistor.

1. Data Storage time begins when a stop pulse reaches Q6 base.
2. Q6 turns off, Q5 on.
3. Q5 collector voltage goes toward ground, forward-biases CR3.
4. CR3 clamps bottom of R8 to ground, Q3 base goes positive.
5. Q3 turns on, clamps Q4 collector to ground.
6. Count pulses at Q4 base cannot affect the collector circuit; therefore, signal gate is closed.
7. During this time Q6 and Q7 collectors are negative.
8. CR8 and CR9 are both reverse-biased, reset control line is unclamped from ground.
9. Reset control line goes negative, which triggers recycle (paragraph 3. 6).

Fig. 3-14 Gate Control -- Data Storage

3.6 RECYCLE

As shown in Figure 3-15, the recycle circuit is a major timing link between control and storage, and between storage and accessory equipment.

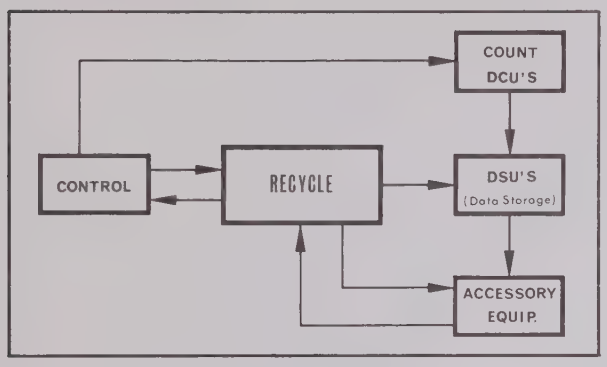


Fig. 3-15 Recycle Sub-System

Recycle rate is controlled by three factors: 1) length of count interval, 2) speed of accessory equipment, and 3) setting of the RECYCLE RATE control. As shown in the Timing Diagram (Figure 3-16), count interval is variable between 10 microseconds and 1 second and recycle time variable between 150 milliseconds and 10 seconds. Before reset can be initiated to ready control circuits for another timing interval, the previous count and recycle intervals must be completed. Also, accessory equipment must be finished in its accumulation of data from the previous cycle. If the count interval is longer than the preset recycle rate, it takes precedent in determining recycle time of the instrument.

3.6.1 Recycle Operation

Circuit logic for recycle operation is shown in Figure 3-17.

3.6.2 Recycle Rate Generator and Control

As stated previously, the three factors that determine recycle rate are counting time (determined by TIME selector setting) speed of accessory equipment, and recycle rate (as set by the RECYCLE RATE control). If recycle rate is longer than count or accessory time, then the Recycle Rate Generator is the determining timing circuit of the instrument.

The Recycle Rate Generator and Control function as shown in Figures 3-18 and 3-19. Figure 3-18 shows the circuit with the generator off. Figure 3-19 shows the generator on.

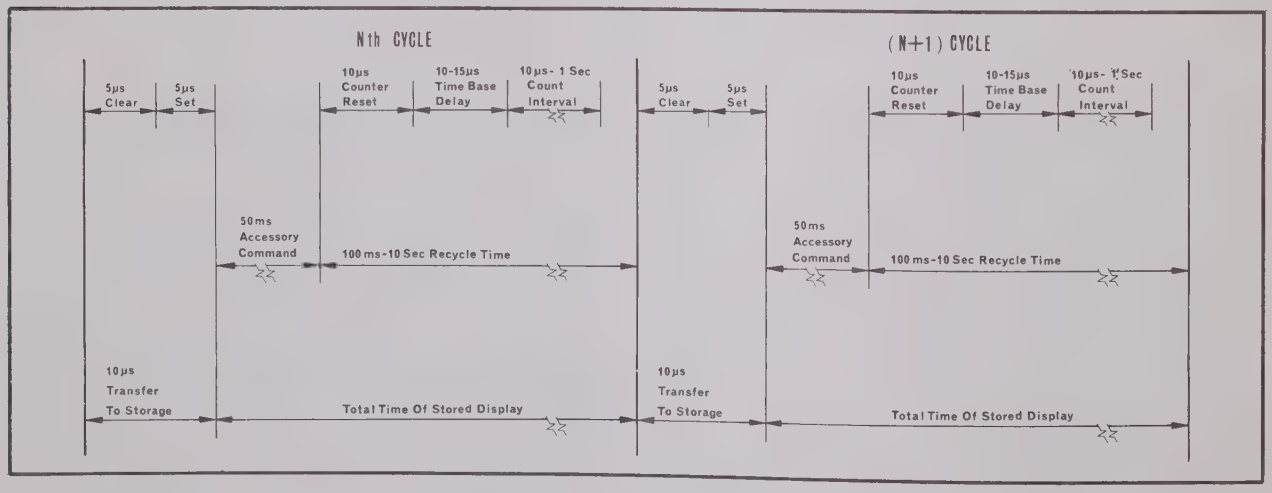


Fig. 3-16 Recycle Timing

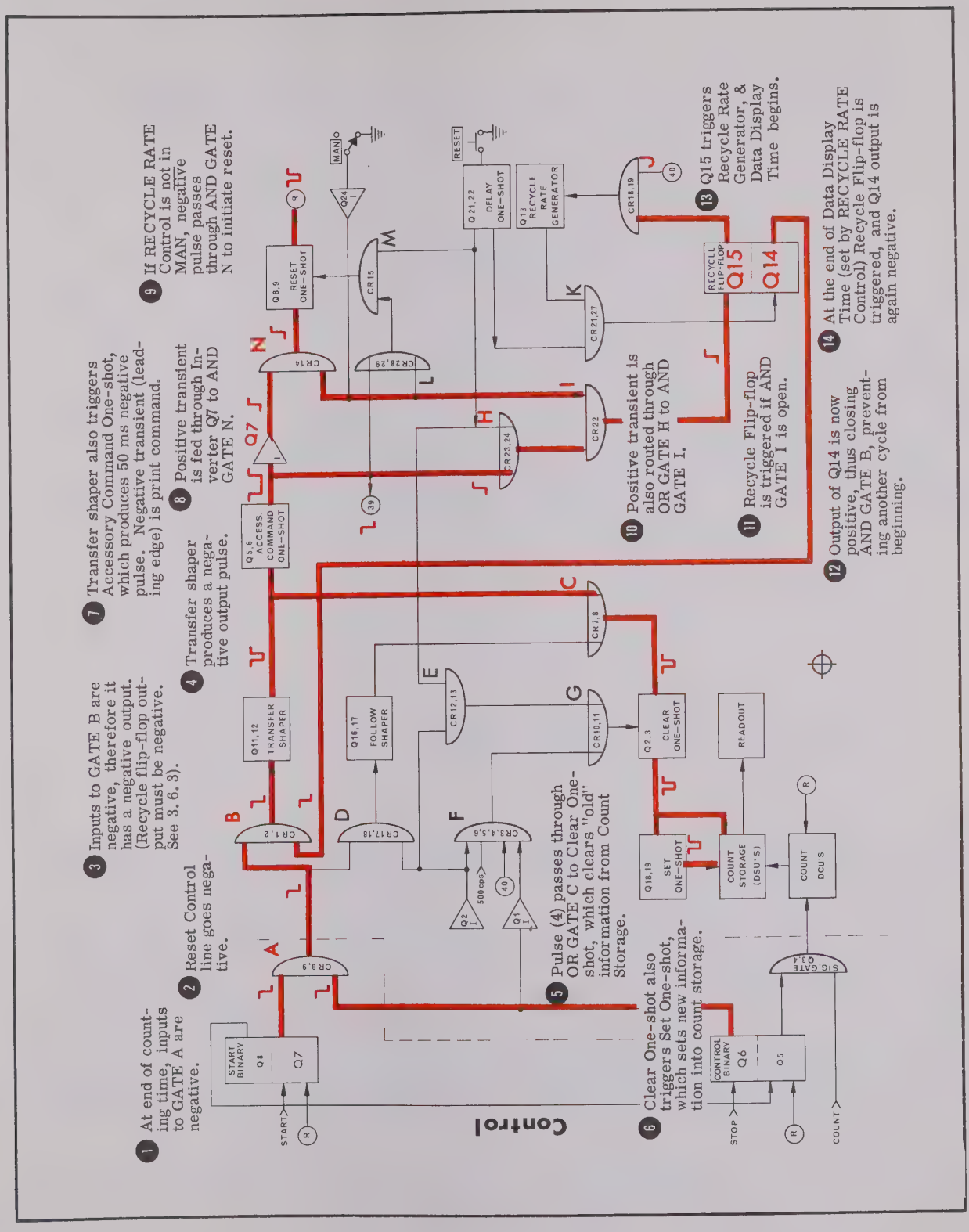
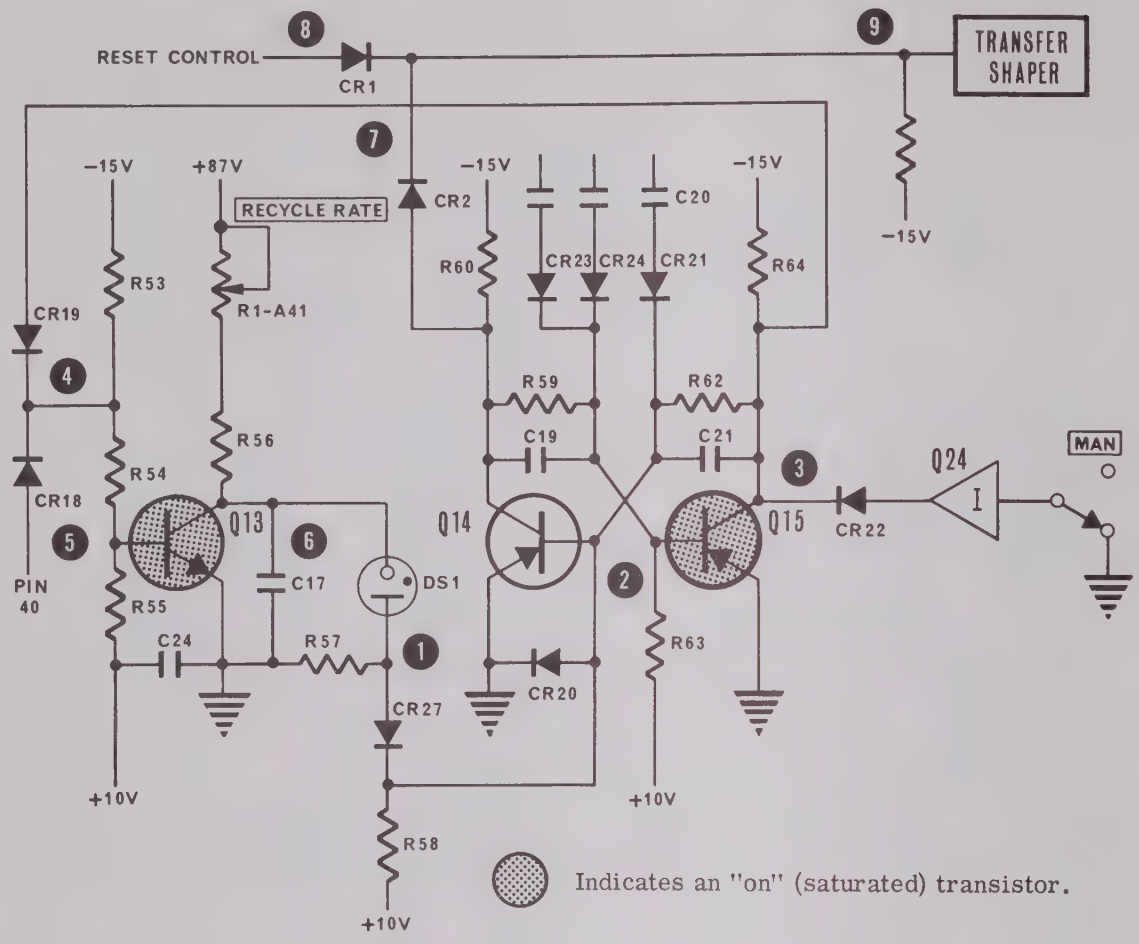
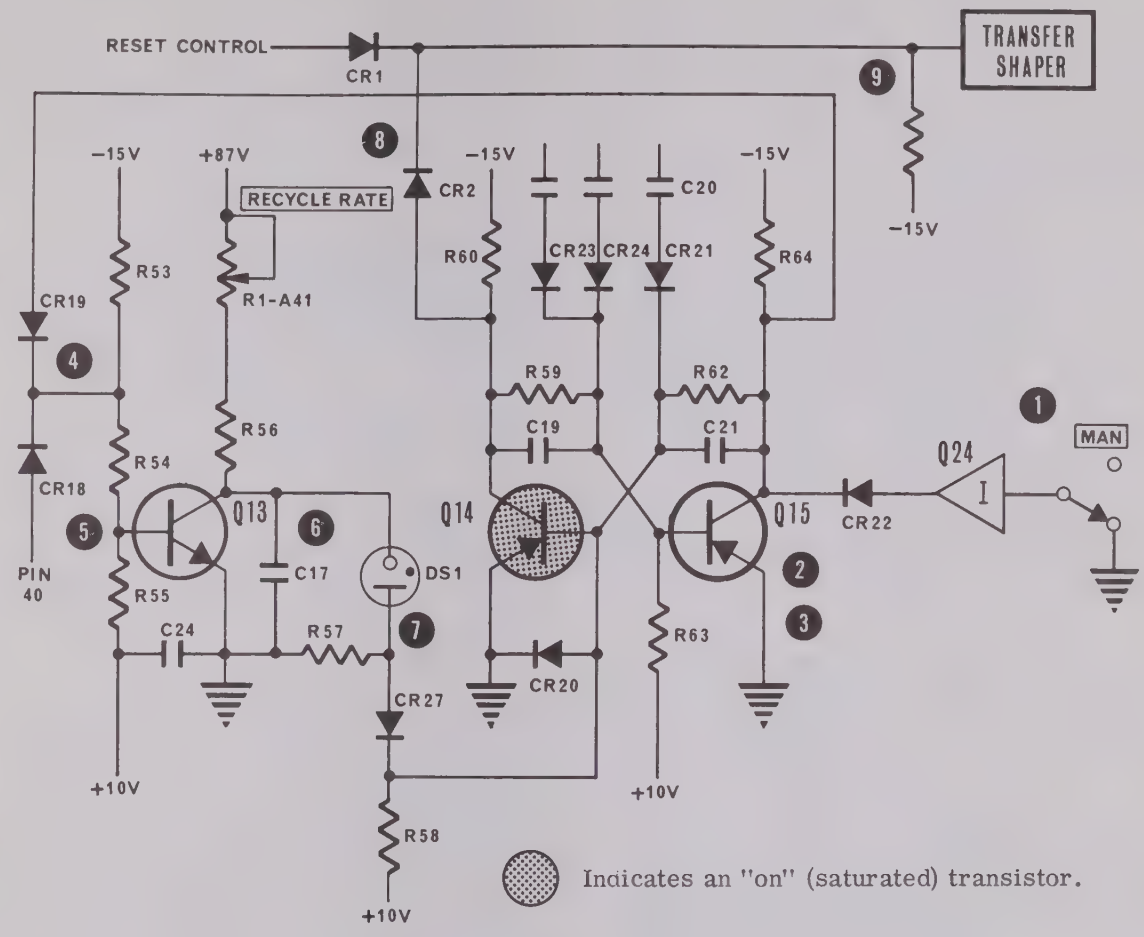

Control
START
STOP
COUNT
START BINARY Q8 Q7
CONTROL BINARY Q6 Q5
CR8,9
CR1,2
Q11,12 TRANSFER SHAPER
Q5,6 ACCESS COMMAND ONE-SHOT
Q8,9 RESET ONE-SHOT
Q7
CR14
Q24
MAN
RESET
Q 21,22 DELAY ONE-SHOT
Q 13 RECYCLE RATE GENERATOR
CR15
CR28,29
CR21,27
CR18,19
RECYCLE FLIP-FLOP Q15 Q14
CR22
CR23,24
CR7,8
CR12,13
CR10,11
Q16,17 FOLLOW SHAPER
CR17,18
CR3,4,5,6
Q2
Q1
500 cps
Q18,19 SET ONE-SHOT
Q2,3 CLEAR ONE-SHOT
COUNT STORAGE (DSU'S)
READOUT
COUNT DCU'S
SIG. GATE Q3,4
A
B
C
D
E
F
G
H
I
K
L
M
N
1 At end of counting time, inputs to GATE A are negative.
2 Reset Control line goes negative.
3 Inputs to GATE B are negative, therefore it has a negative output. (Recycle flip-flop output must be negative. See 3.6.3).
4 Transfer shaper produces a negative output pulse.
5 Pulse (4) passes through OR GATE C to Clear One-shot, which clears "old" information from Count Storage.
6 Clear One-shot also triggers Set One-shot, which sets new information into count storage.
7 Transfer shaper also triggers Accessory Command One-shot, which produces 50 ms negative pulse. Negative transient (leading edge) is print command.
8 Positive transient is fed through Inverter Q7 to AND GATE N.
9 If RECYCLE RATE Control is not in MAN, negative pulse passes through AND GATE N to initiate reset.
10 Positive transient is also routed through OR GATE H to AND GATE I.
11 Recycle Flip-flop is triggered if AND GATE I is open.
12 Output of Q14 is now positive, thus closing AND GATE B, preventing another cycle from beginning.
13 Q15 triggers Recycle Rate Generator, & Data Display Time begins.
14 At the end of Data Display Time (set by RECYCLE RATE Control) Recycle Flip-flop is triggered, and Q14 output is again negative.

Fig. 3-17 Recycle Functional Block Diagram



1. At end of selected recycle time, DS1 fires, producing positive pulse.
2. Positive pulse turns Q14 off, Q15 on.
3. Q15 collector goes positive (from -15 volts to near ground potential).
4. CR19 conducts, clamping bottom of R53 to ground, which electrically removes R53 from divider network R53, 54, 55.
5. Q13 base becomes positive, Q13 turns on and discharges C17.
6. C17 cannot charge since available charging current is bypassed through Q13.
7. Q14 collector is negative; therefore, CR2 turns off.
8. CR2 turns off. CR1 may or may not be of, depending upon selected time base interval vs. recycle time.
9. When both diodes of ⑧ are off, transfer shaper produces negative pulse to begin new cycle, beginning with the accessory command signal.

Fig. 3-18 Recycle Rate Generator - 'Off'



1. With RECYCLE RATE control at MAN, automatic recycle is disabled by holding Q15 collector near ground potential.
2. With Q15 unclamped (switch not in MAN), it can be triggered by a positive pulse from Delay One-Shot or Accessory Command One-Shot.
3. Positive pulse turns Q15 off, Q14 on. Q15 collector goes negative.
4. CR19 turns off, unclamping R53.
5. Q13 base goes negative, Q13 turns off.
6. C17 begins to charge through R56 and R1-A41. Charge time is determined by RECYCLE RATE setting.
7. C17 charges until firing potential of DS1 is reached.
8. Q14 collector is near ground during C17 charge time; therefore, CR2 is conducting.
9. Conduction of CR2 keeps Transfer Shaper input near ground, and it cannot be triggered.

Fig. 3-19 Recycle Rate Generator - 'On'

3.6.3 Delay One-Shot

Consisting of transistors Q21 and Q22, the Delay One-Shot produces a 15 millisecond pulse when triggered by the RESET button. Detailed operating theory of the one-shot is included in Section 3.9; therefore, only the function of the Delay One-Shot with other circuits will be described here.

The base of Q22 goes positive when the RESET button is pressed, thus triggering the one-shot. The positive transient at the collector of Q22 turns Q14 off and Q15 on, thereby turning Q13 on and discharging C17. Approximately 15 milliseconds later the positive transient at the collector of Q22 turns Q15 off, Q14 on, and Q13 off allowing C17 to charge to the potential set by the RECYCLE RATE control.

The positive transient at the collector of Q22 also triggers the Reset One-Shot which resets count DCU's and Gate-control circuits.

3.6.4 Reset One-Shot

The Reset One-Shot is preceded by a buffer amplifier (Q7) and followed by an emitter follower (Q10). Reset is triggered by a positive transient from the Accessory Command One-Shot or by a positive transient from the Delay One-Shot. The reset circuit produces a 10 microsecond negative pulse which resets count DCU's and binaries in the gate-control circuit. See Section 3.9 for further information on the operation of the typical One-Shot.

3.6.5 Accessory Command One-Shot

Triggered by the Transfer Shaper, the Accessory Command One-Shot produces a 50 millisecond negative pulse. The leading edge (negative transient) of this pulse is the print command, which is routed via pin 39 of J9 to the accessory equipment. (See optional equipment in the appended modification section.) Fifty milliseconds after the print command has been issued, the trailing edge (positive transient) triggers the Reset One-Shot and the Recycle control.

3.6.6 Clear and Set One-Shots

Respectively, the Clear and Set One-Shots clear "old" information from the Data Storage Units and set in "new" information.

The Transfer Shaper triggers the Clear One-Shot which resets the binaries of the Data Storage Units. The Clear One-Shot also triggers the Set One-Shot which allows transfer of data from DCU's to DSU's. This process of clearing and setting is described in more detail in the appended DSU manual.

3.7 LEGEND

The legend printed circuit board comprises two separate sections. The front section contains the decoding matrix which controls the unit of measurement nomenclature on the EL panel. The rear section contains the circuits which drive the GATE OPEN light.

3.7.1 Decoding Matrix

The legend decoding matrix is similar to the matrix used in the Data Storage Unit. (See the appended DSU manual.) However, in the legend circuit, switch contacts (rather than transistors) are used to control the on/off voltages to the EL segments.

Figure 3-20 shows the basic decoding circuit, which uses a photoconductor as the variable arm

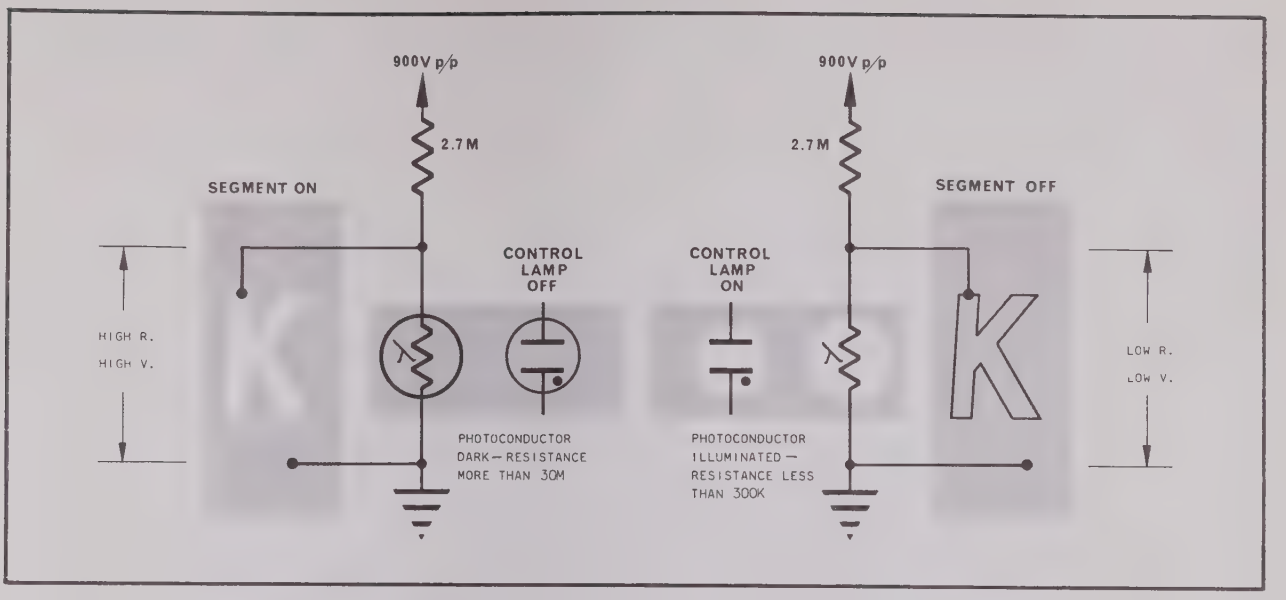


Fig. 3-20 Photoconductor Switching Circuit -- Simplified

of a voltage divider. When the photoconductor is in total darkness, resistance is high. When illuminated by the control lamp, the resistance is low. Thus, an EL segment connected across the photoconductor can be switched on and off by the lamp.

Figure 3-21 is a simplified block diagram of the legend decoding matrix.

3.7.2 GATE OPEN Light

The GATE OPEN light is on during the interval that the signal gate remains open (counting time). Therefore, the light is turned on when the positive output of the start binary drives Q4 on the legend board. Transistor Q4 triggers the one-shot (Q1, Q2), which produces a negative pulse turning Q3 off. With Q3 off, +90 volts is developed across GATE OPEN light DS1. DS1 turns off when the control binary output drives Q3 base positive.

3.8 POWER SUPPLY

3.8.1 Primary Power

AC power is applied through line filter Z1 to the primary winding of power transformer T1. With power applied, 117 volt ac is provided for the oscillator oven control circuit and connector J7.

Relay K1 is energized when POWER switch S5-A is at OFF. With K1 energized, 1) +15 volts is provided for the oscillator circuits, 2) +90 volt supply is disabled, 3) -15 volt output is not available, and 4) fan motor has no power applied. K1 de-energizes when POWER switch is set to ON.

3.8.2 Regulated -15 Volt and +15 Volt Supplies

The -15 volt supply consists of full-wave rectifier CR1; series regulator Q1; and reference amplifier A34Q1, A34Q2, and A34Q3. The +15 volt supply consists of full-wave rectifier CR2;

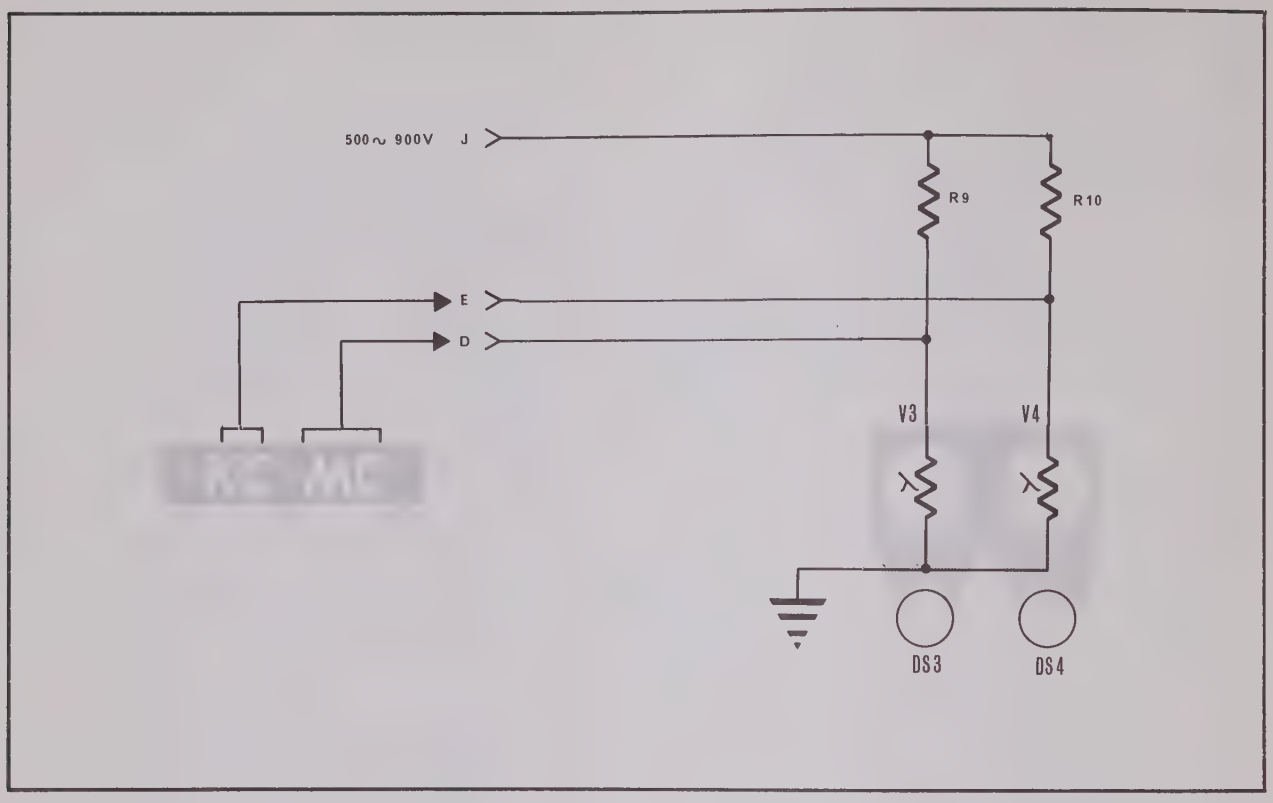


Fig. 3-21 Legend Circuit -- Simplified

series regulator Q2; and reference amplifier A34Q4, A34Q5, and A34Q6. Except for their difference in polarity, the -15 volt and +15 volt supplies are identical. Therefore, only the operation of the -15 volt supply will be described.

A portion of the -15 volts is fed back through divider network R3, R8, and R9 to the base of A34Q3. The output of A34Q3 controls the bias on A34Q2, thereby controlling current flow through A34Q2 to the base of Q1. Transistor A34Q1 acts as a constant current source for A34Q2.

If the -15 volt output begins to go more negative (toward -16 volts), A34Q3 base goes negative, conduction increases, and its collector potential goes positive. The base of A34Q2 goes positive, and current flow (through A34Q2) in the base circuit of Q1 decreases. With less base current, conduction through Q1 decreases, and output voltage decreases (back to -15 volts). The output voltage is maintained at a value set by potentiometer R8.

3.8.3 Regulated +10 Volt Supply

Derived from regulated +15 volts, the +10 volt supply consists of series regulator Q3 and reference amplifier A35Q3 and A35Q4. Changes in load voltage vary the bias on A35Q3, thereby

varying the base current supplied to Q3. Transistor A35Q4 maintains emitter current of A35Q3 at a constant value. Potentiometer R4 sets the output voltage level.

3.8.4 Regulated +90 Volt Supply

The regulated +90 volt supply consists of full-wave rectifier CR3, reference amplifier A34Q7, and series regulator Q4. Operation of this supply is similar to that of the other regulated supplies. Changes in load voltage are reflected through A34Q7 which controls current through Q4. The emitter of A34Q7 is referenced to the +15 volt supply.

3.8.5 EL Supply (500 cps, 900 Volt P-P)

The EL supply comprises a push-pull oscillator (A35Q1, A35Q2) utilizing transformer feedback. See Figure 3-22, simplified schematic of the EL supply.

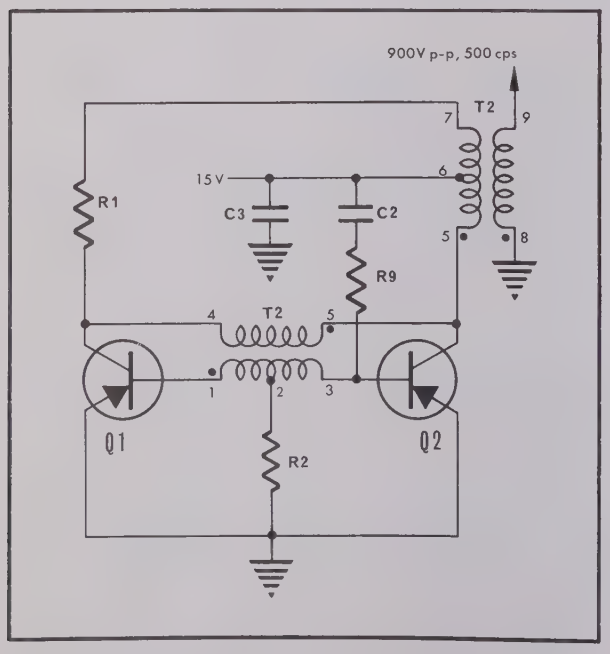


Fig. 3-22 EL Supply -- Simplified

Oscillation is maintained by inverting and feeding back part of the collector signal of each stage to its respective base. Transformer T2 (winding 4-5 and 1-3) provides the required 180 degree phase shift for regenerative feedback. The push-pull output signal is developed across transformer winding 5-7 and is stepped up to 900 volt p-p in winding 8-9. Frequency of oscillation is essentially determined by transformer winding and R1.

3.9 BASIC CIRCUITS

This section describes some of the basic circuits and circuit fundamentals which apply to the Model 6120. Information is intended to give the operator or technician a general understanding of the basic circuits, and no attempt has been made to describe how diodes or transistors function internally.

3.9.1 AND and OR Gate Circuits

The AND circuit is a multiple input circuit which requires both input signals in order to produce an output. Figure 3-23 shows two configurations of the AND circuit.

The OR circuit is a multiple input circuit which requires the presence of only one input signal in order to produce an output. Figure 3-23 shows an OR gate configuration.

3.9.2 Typical Binary

Shown in Figure 3-24 is a typical binary, or "flip-flop", using PNP transistors and positive-pulse steering. The circuit can exist in either of two stable states: Q1 on, Q2 off; or Q1 off, Q2 on. Positive input pulses trigger the binary from one stable state to the other through one of the pulse-steering diodes (CR1 or CR2).

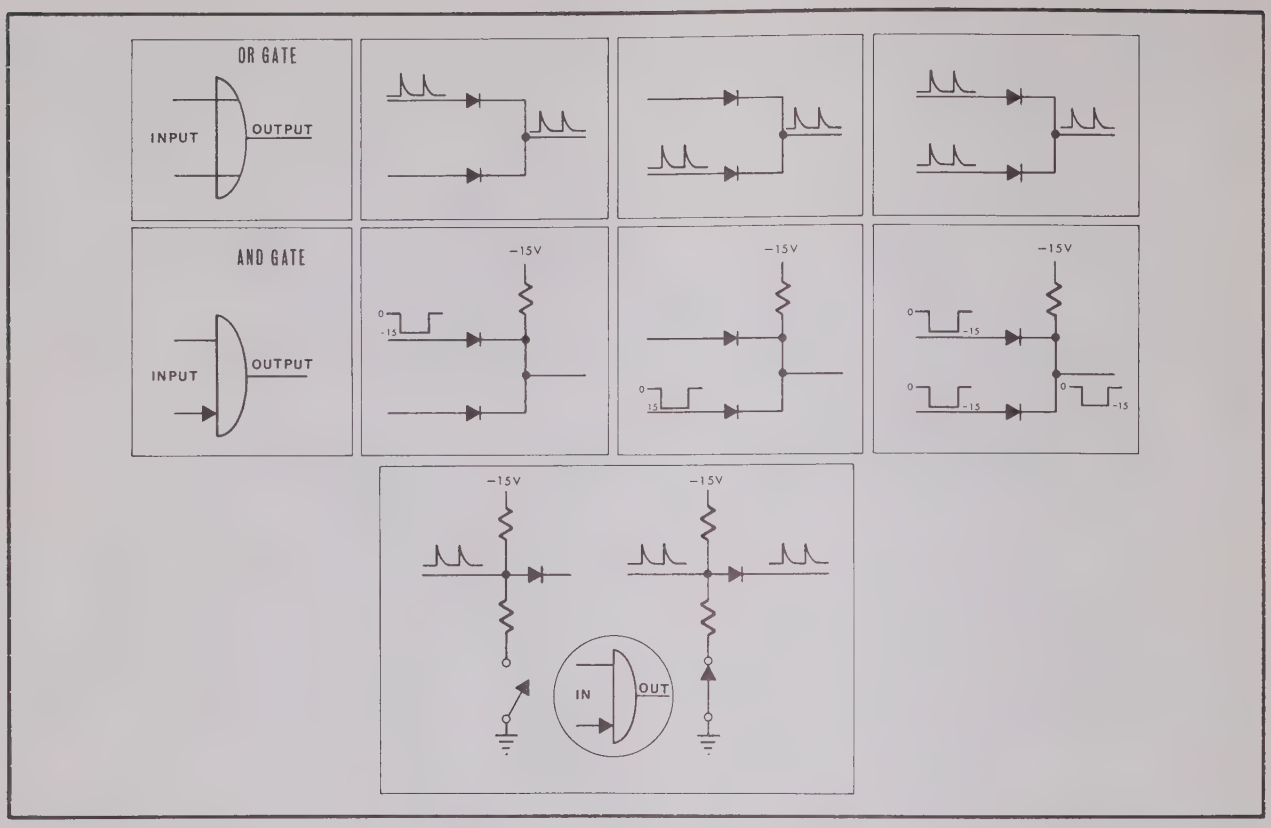


Fig. 3-23 Gate Circuits -- Typical

Assume that transistor Q1 is conducting and transistor Q2 is cut off. A positive input pulse passes through CR1 to the base of Q1, turning Q1 off. As Q1 turns off, load current decreases and the collector potential approaches -15 volts. This negative transient is coupled through capacitor C1 to the base of Q2, turning Q2 on. Current through Q2 increases and its collector potential rises toward ground. Under these conditions, divider network R6-R4 maintains a positive potential at the base of Q1 to keep it cut off. (See Figure 3-24).

The binary remains in this stable state (Q1 off, Q2 on) until the next positive input pulse arrives. At that time, Q2 cuts off, Q1 conducts, and the binary resumes its original state.

3.9.3 Typical One-Shot

A typical "one-shot", or monostable multivibrator, is shown in Figure 3-25. Transistor Q1 is held at cutoff and transistor Q2 at saturation by bias arrangement and transistor regeneration. A negative pulse is applied and the circuit functions until a full cycle is completed. Circuit timing is determined by the values of capacitor C1 and resistor R2.

A negative pulse is applied through coupling capacitor C2 to the base of transistor Q1, and it begins to conduct. The negative voltage at the collector of Q1 begins to fall. This positive transient is coupled to the base of transistor Q2, and forward-bias on Q2 is decreased. Collector

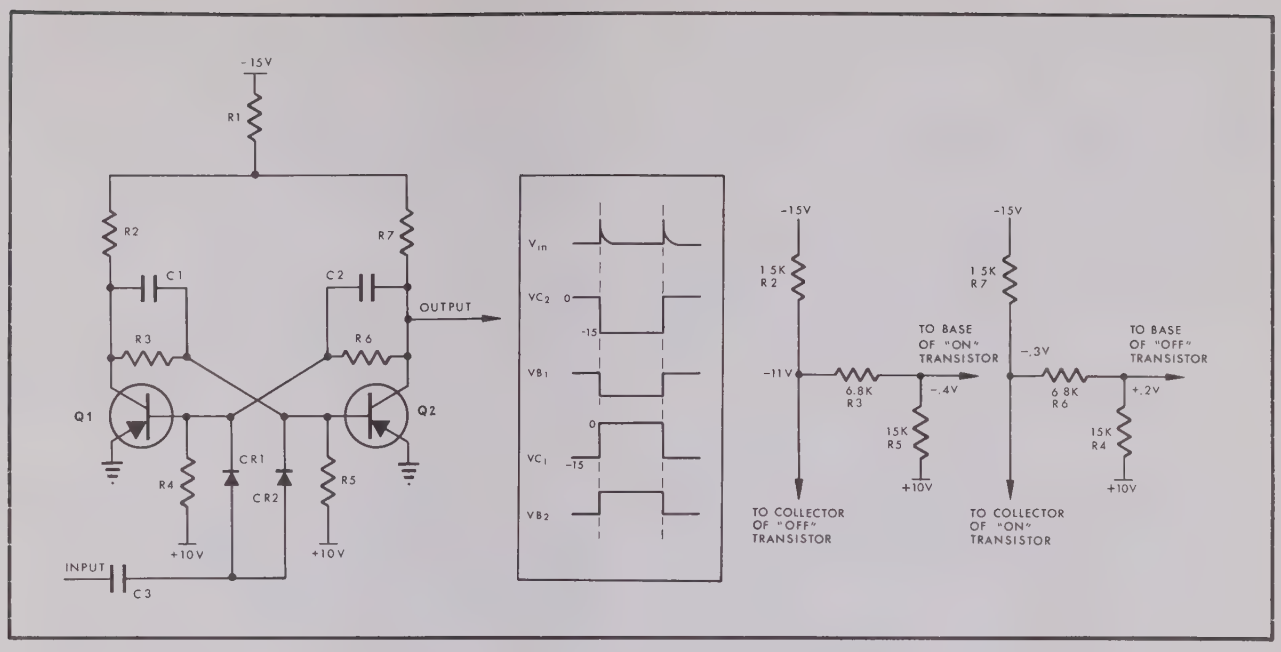


Fig. 3-24 Typical Binary

current of Q2 begins to decrease, and its collector voltage increases negatively. Part of this voltage is coupled through R4 to the base of Q1, increasing its negative potential. This regeneration results in a rapid change of both transistors; it drives Q1 into saturation and Q2 into cutoff. Since capacitor C1 was initially charged to -15 volts, the base of Q2 is at a positive potential of that magnitude (15 volts).

Capacitor C1 begins to discharge through R2 and the low resistance of Q1, and base potential of Q2 becomes less positive. When the base of Q2 becomes slightly negative, Q2 again conducts. Collector potential of Q2 increases positively and is coupled to the base of transistor Q1, driving it to cutoff. Transistor Q1 is again at cutoff and Q2 at saturation. This stable state is maintained until another negative pulse arrives to trigger the circuit.

3.9.4 Voltage Discriminator

The voltage discriminator (Schmitt trigger circuit), shown in Figure 3-26, differs from the binary in that one of the coupling networks is replaced by a common-emitter resistor. This arrangement provides additional regenerative feedback, thus obtaining a faster switching time.

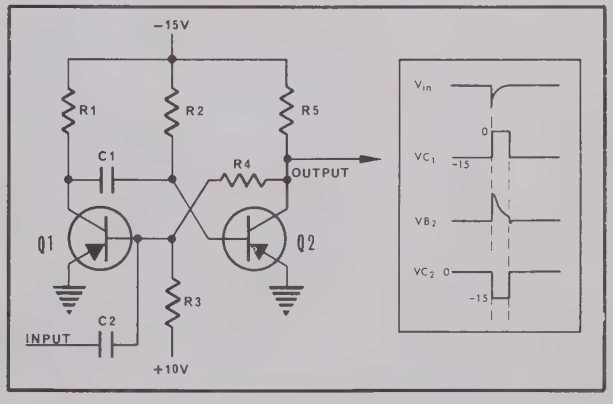


Fig. 3-25 Typical One-Shot Circuit

The circuit can exist in either of two stable states: Q1 on, Q2 off, or Q1 off, Q2 on. Assuming that transistor Q1 is off, its collector voltage is at -15 volts. This negative voltage, coupled through R3, forward biases Q2 with a base potential of about -5 volts. Current flow from the emitter of transistor Q2 through R4 maintains the emitter of transistor Q1 at a negative potential. The reverse bias now developed between emitter and base of Q1 maintains the cutoff condition.

A negative-going input signal overcomes the reverse bias on the base of Q1 and it conducts. The collector potential of Q1 decreases (becomes less negative, and this transient is coupled to the base of Q2. Emitter current of Q2 decreases, lowering the potential across R4. The emitter of Q1 becomes less negative, reducing the reverse bias and increasing collector current. This regeneration continues until Q1 is saturated and Q2 is cut off.

This stable condition (Q1 on, Q2 off) continues until the input becomes more positive, at which time the reverse process takes place. The output of the Schmitt circuit is a square-wave, and does not depend upon the shape of the input waveform.

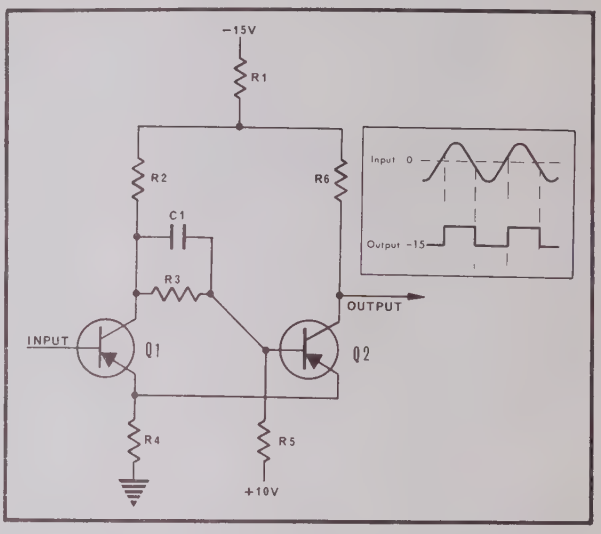


Fig. 3-26 Typical Voltage Discriminator

SECTION 4
SERVICING

4.1 GENERAL

This section provides adjustment procedures for Model 6120. Additional maintenance data is covered in the appended DSU and DCU instruction manuals.

4.1.1 Required Test Equipment

Table 4-1 lists the recommended test instruments for servicing the counter. Other instruments may be used if their specifications meet or exceed the requirements listed.

4.1.2 Cabinet Removal

As shown in Figure 4-1, two screws at the rear of the instrument hold the top cover in place. After removing these screws, slide the top cover back and then upwards.

Figure 4-2 shows the screws that hold the bottom cover to the main chassis.

4.1.3 Printed Circuit Board Identification

Table 4-2 lists the printed circuit boards used in the instrument.

4.1.4 Printed Circuit Board Identification

Use Figure 4-3 to locate assemblies and components which are mounted on the main chassis. Components on printed circuit boards can be located using the layout drawing which is printed next to the schematic of each assembly.

4.1.5 Extender Boards

Two extender boards have been supplied with the instrument to provide easy access to components and test points on printed circuit boards during operation. These boards are stored inside the Model 696 Basic Plug-In.

Table 4-1 Test Equipment

Instrument	Required Specifications	Recommended Instrument
Oscilloscope	50 mc bandwidth 3.5 nanosecond rise-time	Tektronix Model 581 with Type 80 and 82 Plug-ins
Signal Generator	1 cps to 100 kc 100 millivolt rms output	Accurate Instrument Corp. Model 5A51
Signal Generator	100 kc to 25 mc 100 millivolt rms output	Measurements Corp.
Volt-Ohmmeter	100,000 ohms/v dc	Simpson Model 269
Auto Transformer	0-130 volts ac, 60 cps	Variac Model W5MT3A

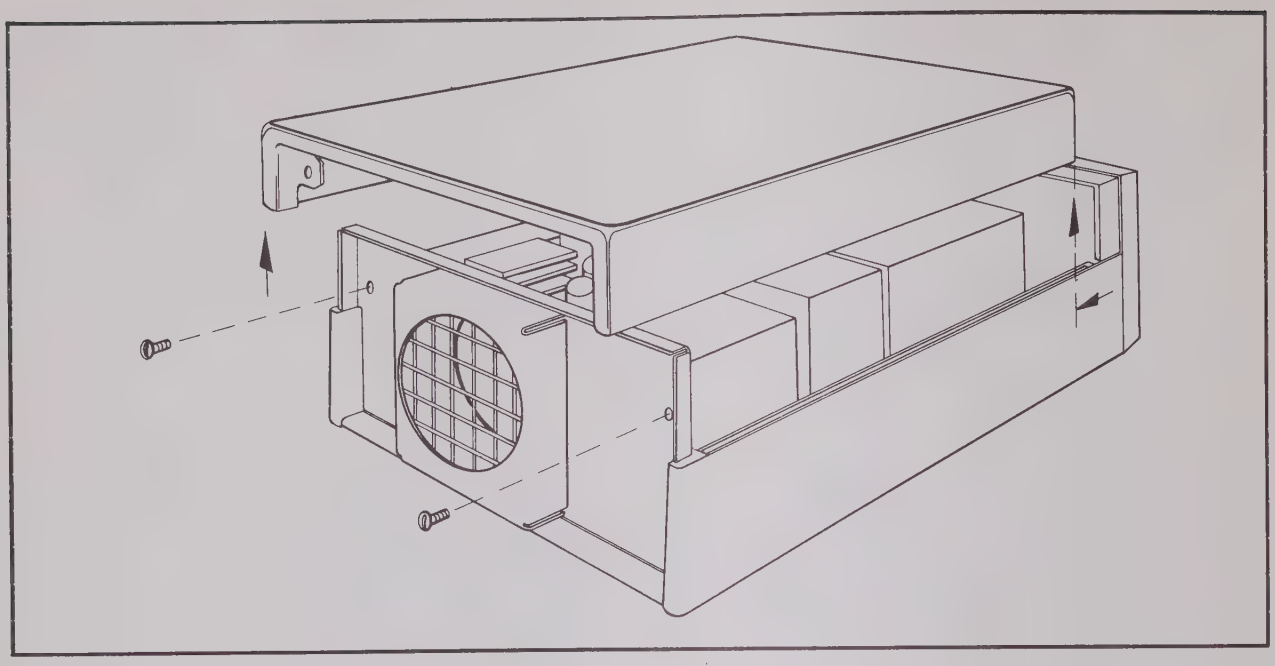


Fig. 4-1 Top Cover Removal

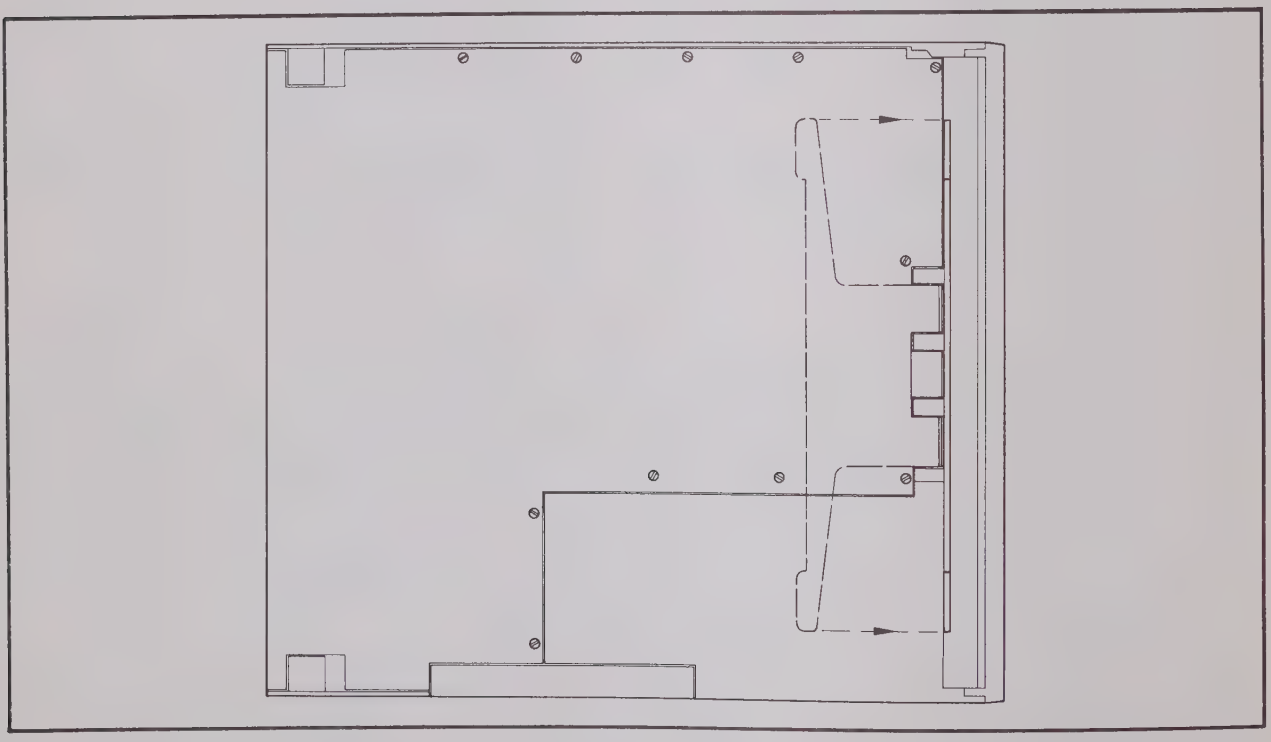


Fig. 4-2 Bottom Cover

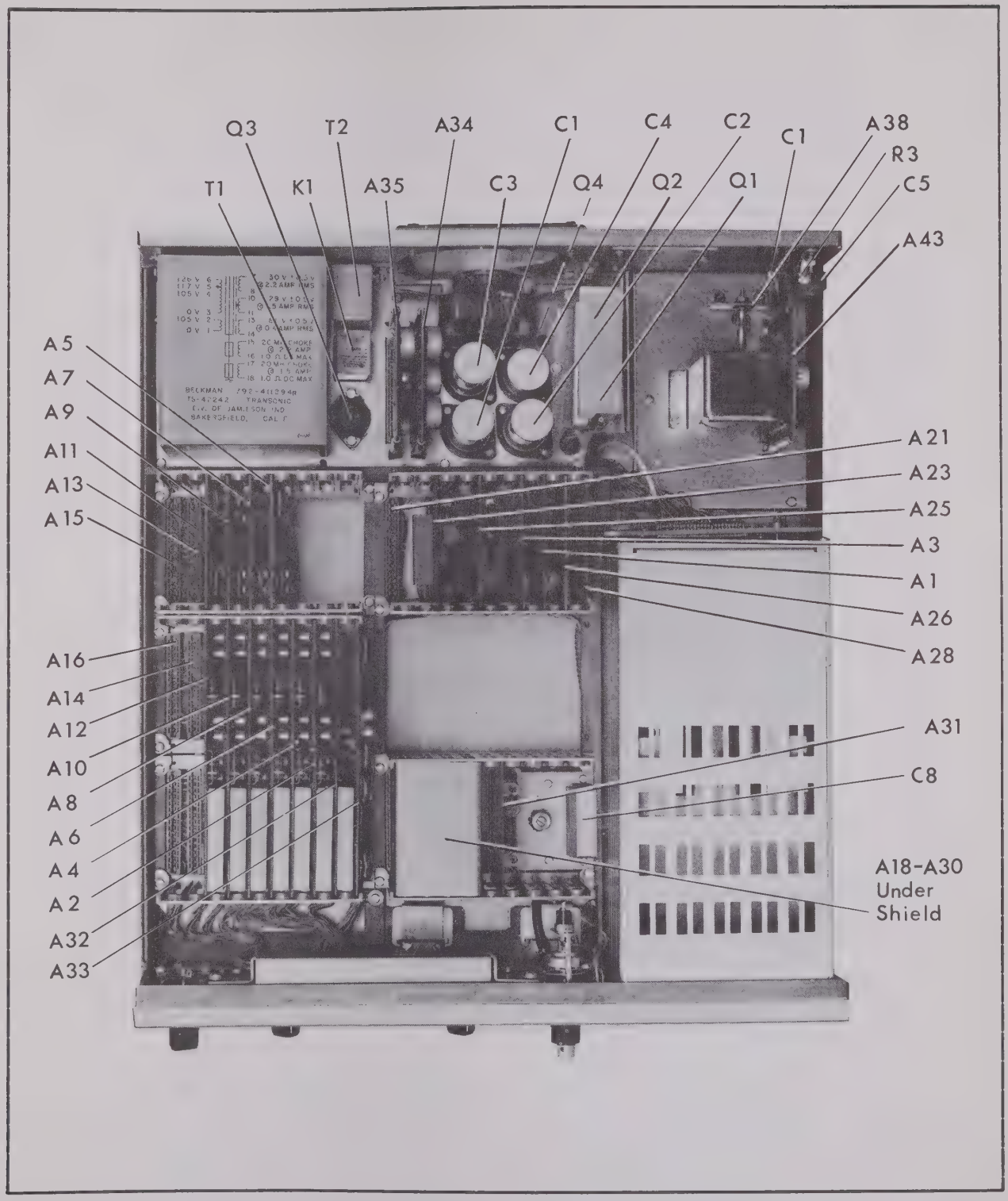


Fig. 4-3A Component Location - Top View

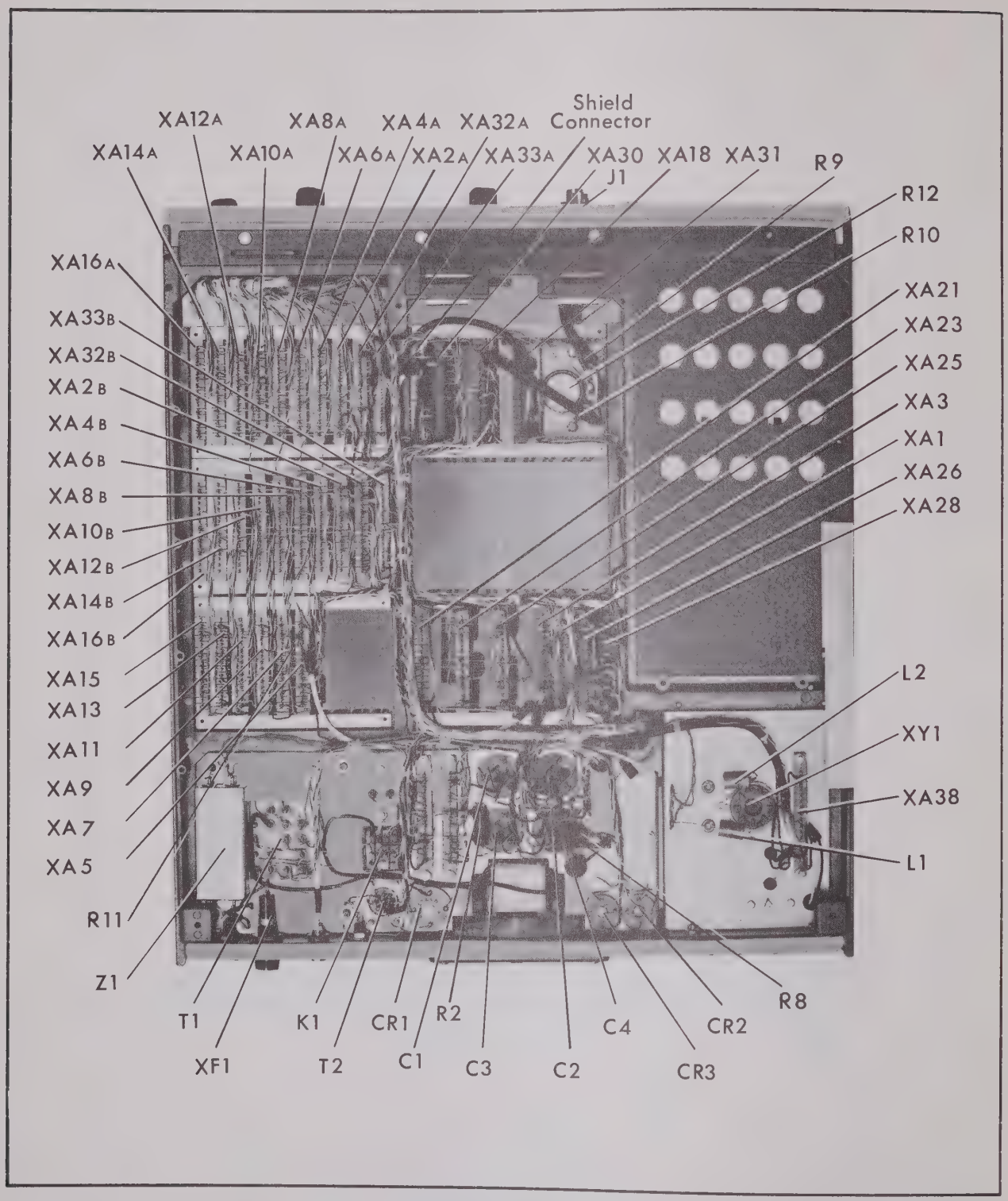


Fig. 4-3B Component Location - Bottom View

Table 4-2 Printed Circuit Board Identification

Printed Circuit Board Detail Number	Description
A1	Model 870 DCU
A2, A4, A6, A8, A10, A12	Data Storage Unit
A3	Model 860 DCU
A5, A7, A9, A11	Model 850 DCU
A18	Input Circuit
A23	Second Divider
A25	First Divider
A26	F Logic
A28	Control
A30	Time Base Logic
A31	1-10 Mc Multiplier
A32	Legend
A33	Recycle
A34	Regulator
A35	EL Supply
A43	1 Mc Oscillator

4.1.6 Plug-Ins

Unless other plug-ins are used, the Model 696 must be installed in the instrument for correct operation. Schematic diagram No. 64A-6100-001 shows the wiring of P6 in the Model 696. Instruction manuals are available for each of the other plug-in units.

4.2 ADJUSTMENTS

4.2.1 Power Supply Adjustments

The regulated power supply adjustments are located on the Regulator Board (A34) and the EL Supply Board (A35). The -15 V (R8), +15 V (R14), and +90 V (R21) adjustments are on A34. The +10 V adjustment (R4) is on A35. Figure 4-4 shows the location of the adjustments.

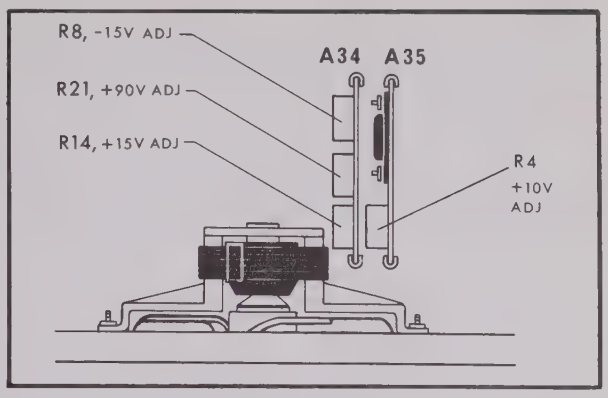


Fig. 4-4 Power Supply Adjustments

4.2.1.1 Adjustment Procedure

CAUTION

Do not remove the Regulator Board (A34) from its receptacle without first unplugging the ac line cord from its power source.

1) Use a voltmeter of at least 1% accuracy. Voltage measurements are referenced to chassis ground.

2) Use Figure 4-5 to locate power supply test points.

3) Remove Regulator Board from its receptacle. Insert extension board into Regulator Board receptacle (XA34) and insert Regulator Board into extension board.

4) Adjust R14 for +15 volts, ±0.2 volt.

5) Adjust R8 for -15 volts, ±0.2 volt.

6) Adjust R21 for +90 volts, ±0.1 volt.

7) Remove extension board and return Regula- Board to its receptacle.

8) Remove EL Supply Board from its receptacle (XA35). Insert extension board into

XA35 and insert EL Supply Board into extension board.

9) Adjust R4 for +10 volts, ±0.2 volt.

10) Return EL Supply Board to its receptacle.

4.2.2 Oscillator Adjustment

4.2.2.1 Procedure

Adjustment of the oscillator frequency is seldom required. When necessary use this procedure:

1) Adjustment of C1
   a) Use Figure 4-6 to locate trimmer adjustment (FREQ ADJ).
   b) Use an oscilloscope (such as Tektronix Model 531) of at least 10 megohms input impedance paralleled with approximately 15 pf; otherwise, loading may cause shift in oscillator frequency.

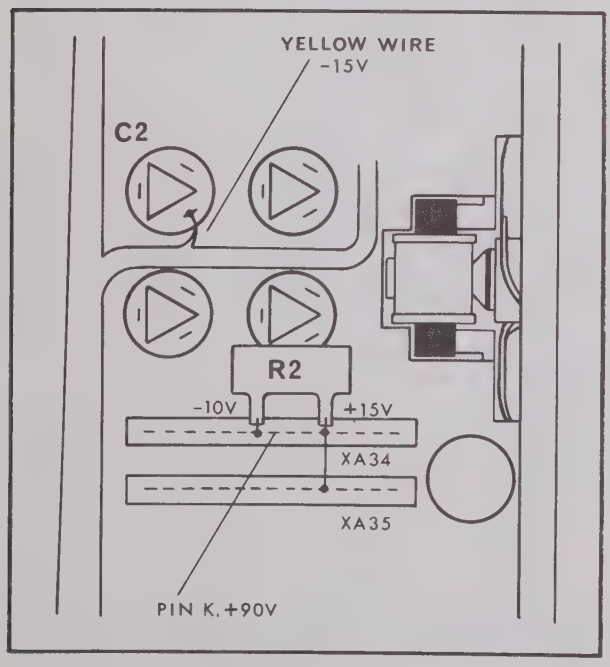


Fig. 4-5 Power Supply Test Points

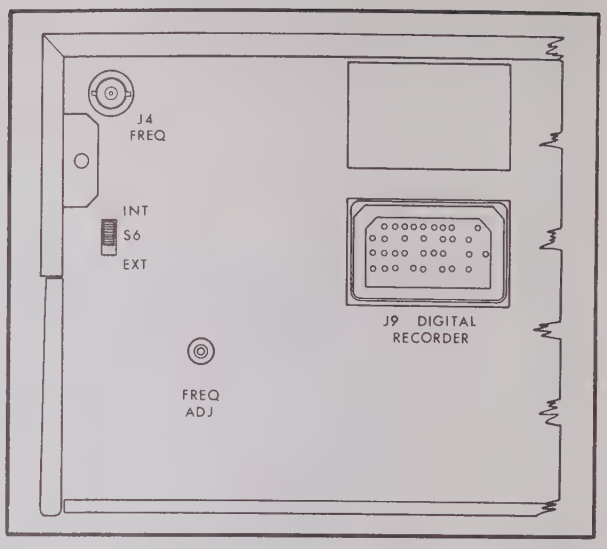


Fig. 4-6 Rear Panel View Showing Location of Crystal Adjust (FREQ ADJ)

   c) Connect the output from FREQ Jack J4 to the vertical input of the scope. Then, couple a 1 mc standard to the horizontal input and adjust C1 for a circular Lissajous pattern indicating equal frequencies.

4.2.3 Multiplier Adjustments

An incorrect reading in TEST may indicate that the 1-10 mc multiplier is out of adjustment. See Table 2-6 in Section 2 for correct TEST readings. To adjust the multiplier, use this procedure:

1) Turn MODE selector to TEST and TIME selector to 10μSEC.

2) Place oscilloscope probe on pin C of A31 (10 mc output). See Figures 4-7 and 4-8.

3) With a non-metallic tuning wand adjust inductors L1 and L2 for maximum output at

10 mc. Output should be at least 2.0 volts peak-to-peak.

NOTE

The 10 mc signal will contain 1 mc modulation of approximately 0.2 volt peak-to-peak.

4.2.4 TRIGGER LEVEL Adjustment Procedure

1) Set MODE selector to OPERATE.

2) Set TIME selector to 1 SEC.

3) Set RECYCLE control for approximately 1 second display.

4) Couple a ~~100~~ 150 mv rms signal to INPUT.

5) Adjust the INPUT LEVEL adjust until a consistent reading is obtained on the display panel.

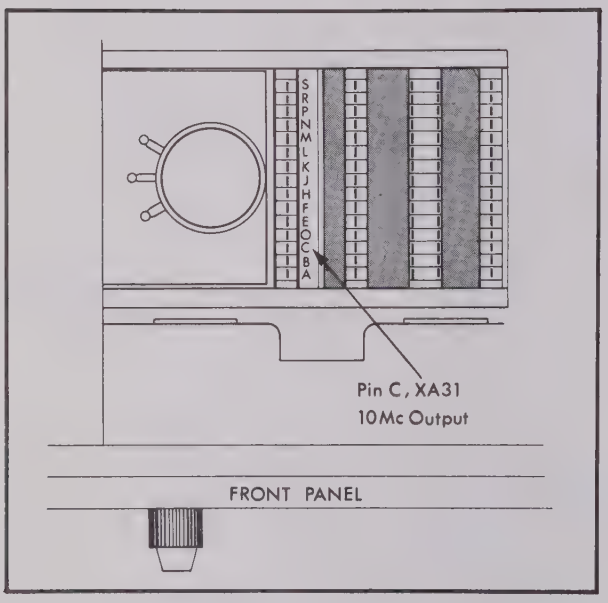


Fig. 4-7 Bottom View of Model 6120 Showing Multiplier Test Point

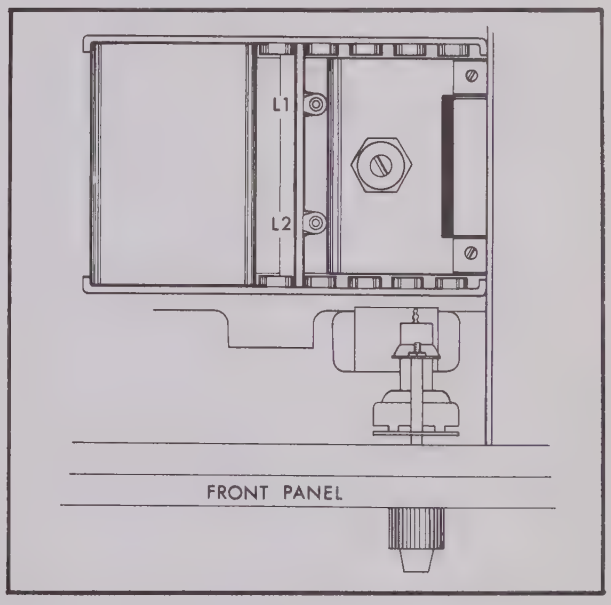


Fig. 4-8 Top View of Model 6120 Showing Multiplier and Input Level Adjust

SECTION 5
PARTS LISTS

NOTE

The sub-assemblies contained in this parts list are identified as follows:

Model 870 DCU	P. C. Board A1	Control	P. C. Board A28
Data Storage Unit	P. C. Boards A2, A4, A6, A8, A10, A12	Time Base Logic	P. C. Board A30
		1-10 Mc Multiplier	P. C. Board A31
Model 860 DCU	P. C. Board A3	Legend	P. C. Board A32
Model 850 DCU	P. C. Boards A5, A7, A9, A11	Recycle	P. C. Board A33
25 Mc Input Amplifier	P. C. Board A18	Regulator	P. C. Board A34
2nd Divider	P. C. Board A23	E. L. Supply	P. C. Board A35
1st Divider	P. C. Board A25	1 Mc Oscillator	P. C. Board A38
F Logic	P. C. Board A26	Model 696	Basic Plug-In

* *

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A1	887-411655	Model 870 DCU Refer to appended manual	Beckman/Berkeley	1
A2	887-412638	Data Storage Unit Refer to appended manual	B/B	6
A3	887-411654	Model 860 DCU Refer to appended manual	B/B	1
A4		Same as A2		
A5	887-411653	Model 850 DCU Refer to appended manual	B/B	4
A6		Same as A2		
A7		Same as A5		
A8		Same as A2		
A9		Same as A5		
A10		Same as A2		
A11		Same as A5		
A12		Same as A2		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A18	887-414707	25 Mc Amplifier	B/B	1
A18C1	637-824028	Capacitor, F. Mica, 1000pf, 300V, 5%	Arco DM16E102J-300	1
A18C2	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	12
A18C3 thru A18C14		Same as A18C2		
A18C15	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	2
A18C16		Same as A18C15		
A18CR1	755-819903	Diode, Zener, Silicon, 7V	Transitron 1N763-2	1
A18CR2	755-815561	Diode, Sil., 75PIV, 10 ma, 1V min. fwd.	Continental CD6111	2
A18CR3		Same as A18CR2		
A18L1	795-819899	Inductor, Fixed, R.F., 0.22 μh	Delavan 1840-02	1
A18L2	795-819898	Inductor, Fixed, R.F., 0.47 μh	Delavan 1840-06	2
A18L3		Same as A18L2		
A18L4	795-807878	Inductor, Fixed, R.F., 0.010mh	National NA-10.0-I	1
A18Q1	755-414751	Transistor, Silicon, Special	B/B	1
A18Q2	755-419596	Transistor, Special	B/B	3
A18Q3	755-409895	Transistor, Special	B/B	1
A18Q4	755-823145	Transistor, Germanium, PNP, 300mw, max.	Motorola 2N1143	1
A18Q5 & A18Q6		Same as A18Q2		
A18Q7 & A18Q8	755-817811	Transistor, Germanium, PNP, 150mw, max.	Motorola 2N961	2
A18R1	601-000897	Resistor, F. Comp., 2.2K, 1/2W, 5%	Allen Bradley EB2225	2
A18R2	601-015449	Resistor, F. Comp., 1.8K, 1/2W, 5%	Allen Bradley EB1825	1
A18R3	601-822366	Resistor, F. Comp., 20K, 1/4W, 5%	Allen Bradley CB2235	1
A18R4	601-822297	Resistor, F. Comp., 4.7K, 1/2W, 5%	Allen Bradley CB4725	2
A18R5	601-015050	Resistor, F. Comp., 5.6K, 1/2W, 5%	Allen Bradley EB5625	1
A18R6	601-823389	Resistor, F. Comp., 68Ω, 1/4W, 5%	Allen Bradley CB6805	5
A18R7		Same as A18R6		
A18R8		Same as A18R4		
A18R9	601-822544	Resistor, F. Comp., 1.8K, 1/4W, 5%	Allen Bradley CB1825	1
A18R10	601-822308	Resistor, F. Comp., 1K, 1/4W, 5%	Allen Bradley CB1025	1
A18R11		Same as A18R1		
A18R12		Same as A18R6		
A18R13	601-823397	Resistor, F. Comp., 5.6K, 1/4W, 5%	Allen Bradley CB5625	1
A18R14		Same as A18R6		
A18R15	601-823379	Resistor, F. Comp., 10Ω, 1/4W, 5%	Allen Bradley CB1005	2
A18R16	601-822327	Resistor, F. Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	1
A18R17	601-823390	Resistor, F. Comp., 120Ω, 1/4W, 5%	Allen Bradley CB1215	1
A18R18		Same as A18R6		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty. / Ass'y
A18R19		Same as A18R15		
A18R20	607-824999	Resistor, Metal Film, 221Ω, 1/4W, 1%	I. R. C. MEA-T-2	1
A18R21	601-822527	Resistor, F. Comp., 1.5K, 1/4W, 5%	Allen Bradley CB1525	1
A18R22	607-827000	Resistor, Metal Film, 475Ω, 1/4W, 1%	I. R. C. MEA-T-2	1
A18R23	607-824997	Resistor, Metal Film, 249Ω, 1/2W, 1%	I. R. C. MEB-T-2	1
A18R24	601-024744	Resistor, F. Comp., 180Ω, 1/2W, 5%	Allen Bradley EB1815	2
A18R25		Same as A18R24		
A18R26	607-824998	Resistor, Metal Film, 178Ω, 1/4W, 1%	I. R. C. MEA-T-2	1
A18R27	607-824996	Resistor, Metal Film, 267Ω, 1/2W, 1%	I. R. C. MEB-T-2	1
A18R28	601-823912	Resistor, F. Comp., 470K, 1/4W, 5%	Allen Bradley CB4745	1
A18R29	601-823916	Resistor, F. Comp., 1M, 1/4W, 5%	Allen Bradley CB1055	1
	864-412958	Pad, Converter, Transistor	B/B	8
	776-827315	Heat Sink	B/B	2
		* *		
A23	887-422003	Second Divider	B/B	1
A23C1	651-836668	Capacitor, F. Mylar, 0.01μf, 50V, 5%	Elpac K5P103J	1
A23C2	633-804710	Capacitor, F. Cerm., 0.0022μf, 600V, 10%	Erie Elect. 811-.0022	3
A23C3	637-822908	Capacitor, F. Mica, 330pf, 500V, 5%	Electromotive DM15	9
A23C4 & A23C5		Same as A23C3		
A23C6	651-836669	Capacitor, F. Mylar, 0.1μf, 50V, 5%	Elpac K5P104J	1
A23C7		Same as A23C2		
A23C8 thru A23C10		Same as A23C3		
A23C11	651-836667	Capacitor, F. Mylar, 1μf, 50V, 5%	Elpac K5P105J	1
A23C12		Same as A23C2		
A23C13 thru A23C15		Same as A23C3		
A23CR1	755-815561	Diode, Silicon, 75PIV, 10ma, 1V min. fwd.	Fairchild 1N3064	12
A23CR2 thru A23CR12		Same as A23CR1		
A23Q1	755-417845	Transistor, Special	B/B	9
A23Q2	755-817964	Transistor, Silicon, NPN, 600mw max.	P. S. I. 2N1420	3
A23Q3 thru A23Q5		Same as A23Q1		
A23Q6		Same as A23Q2		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A23Q7 thru A23Q9		Same as A23Q1		
A23Q10		Same as A23Q2		
A23Q11 & A23Q12		Same as A23Q1		
A23R1	601-822297	Resistor, F. Comp., 4.7K, 1/4W, 5%	Allen Bradley CB4725	6
A23R2	607-836664	Resistor, F. Film, 649K, 1/4W, 1%	Electra MF6C-TO	3
A23R3	601-823908	Resistor, F. Comp., 220K, 1/4W, 5%	Allen Bradley CB2245	3
A23R4	601-823902	Resistor, F. Comp., 47K, 1/4W, 5%	Allen Bradley CB4735	6
A23R5	601-823906	Resistor, F. Comp., 150K, 1/4W, 5%	Allen Bradley CB1545	3
A23R6	601-822335	Resistor, F. Comp., 27K, 1/4W, 5%	Allen Bradley CB2735	3
A23R7	601-822303	Resistor, F. Comp., 18K, 1/4W, 5%	Allen Bradley CB1835	3
A23R8		Same as A23R4		
A23R9	601-822527	Resistor, F. Comp., 1.5K, 1/4W, 5%	Allen Bradley CB1525	6
A23R10		Same as A23R9		
A23R11	601-823397	Resistor, F. Comp., 5.6K, 1/4W, 5%	Allen Bradley CB5625	6
A23R12		Same as A23R11		
A23R13	601-822334	Resistor, F. Comp., 22K, 1/4W, 5%	Allen Bradley CB2235	6
A23R14		Same as A23R13		
A23R15 & A23R16		Same as A23R1		
A23R17		Same as A23R2		
A23R18		Same as A23R3		
A23R19		Same as A23R4		
A23R20		Same as A23R5		
A23R21		Same as A23R6		
A23R22		Same as A23R7		
A23R23		Same as A23R4		
A23R24 & A23R25		Same as A23R9		
A23R26 & A23R27		Same as A23R11		
A23R28 & A23R29		Same as A23R13		
A23R30 & A23R31		Same as A23R1		
A23R32		Same as A23R2		
A23R33		Same as A23R3		
A23R34		Same as A23R4		
A23R35		Same as A23R5		
A23R36		Same as A23R6		
A23R37		Same as A23R7		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A23R38		Same as A23R4		
A23R39 & A23R40		Same as A23R9		
A23R41 & A23R42		Same as A23R11		
A23R43 & A23R44		Same as A23R13		
A23R45		Same as A23R1		
	864-412958	Transistor Pads, Mounting	B/B	12
		* *		
A25	887-422002	First Divider	B/B	1
A25C1	637-822253	Capacitor, F. Mica, 200pf, 500V, 5%	Electromotive DM15	1
A25C2	637-822976	Capacitor, F. Mica, 33pf, 500V, 5%	Electromotive DM15	4
A25C3 thru A25C5		Same as A25C2		
A25C6	637-822757	Capacitor, F. Mica, 1000pf, 100V, 10%	Electromotive DM15C-102K-100	1
A25C7	637-822908	Capacitor, F. Mica, 330pf, 500V, 5%	Electromotive DM15	8
A25C8 thru A25C10		Same as A25C7		
A25C11	651-836668	Capacitor, F. Mylar, 0.01μf, 50V, 5%	Elpac K5P103J	1
A25C12 thru A25C15		Same as A25C7		
A25CR1	755-815561	Diode, Silicon, 75PIV, 10ma, 1V min. fwd.	Fairchild 1N3064	13
A25CR2 thru A25CR13		Same as A25CR1		
A25Q1	755-824880	Transistor, Germanium, PNP, 150mw. 10 ma	Motorola 2N960	3
A25Q2	755-419596	Transistor, Special	B/B	4
A25Q3 & A25Q4		Same as A25Q1		
A25Q5	755-417845	Transistor, Special	B/B	6
A25Q6		Same as A25Q2		
A25Q7 thru A25Q9		Same as A25Q5		
A25Q10		Same as A25Q2		
A25Q11 & A25Q12		Same as A25Q5		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A25Q13		Same as A25Q2		
A25R1	601-822527	Resistor, F. Comp., 1.5K, 1/4W, 5%	Allen Bradley CB1525	14
A25R2	607-825325	Resistor, F. Film, 26.7K, 1/4W, 1%	Electra CEBTO	1
A25R3	601-822324	Resistor, F. Comp., 10K, 1/4W, 5%	Allen Bradley CB1035	6
A25R4	601-822295	Resistor, F. Comp., 2.7K, 1/4W, 5%	Allen Bradley CB2725	1
A25R5	601-822296	Resistor, F. Comp., 3.3K, 1/4W, 5%	Allen Bradley CB3325	1
A25R7	601-822299	Resistor, F. Comp., 6.8K, 1/4W, 5%	Allen Bradley CB6825	3
A25R8		Same as A25R3		
A25R9 & A25R10		Same as A25R1		
A25R11	601-823397	Resistor, F. Comp., 5.6K, 1/4W, 5%	Allen Bradley CB5625	6
A25R12		Same as A25R11		
A25R13	601-822334	Resistor, F. Comp., 22K, 1/4W, 5%	Allen Bradley CB2235	8
A25R14		Same as A25R13		
A25R15	601-822327	Resistor, F. Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	2
A25R16		Same as A25R1		
A25R17	607-826515	Resistor, F. Film, 60.4K, 1/4W, 1%	Electra CEBTO	1
A25R18		Same as A25R13		
A25R19	601-822297	Resistor, F. Comp., 4.7K, 1/4W, 5%	Allen Bradley CB4725	2
A25R20		Same as A25R3		
A25R21		Same as A25R1		
A25R22		Same as A25R7		
A25R23		Same as A25R3		
A25R24 & A25R25		Same as A25R1		
A25R26 & A25R27		Same as A25R11		
A25R28 & A25R29		Same as A25R13		
A25R30 & A25R31		Same as A25R1		
A25R32	607-836665	Resistor, F. Film, 66.5K, 1/4W, 1%	Electra MF6C-TO	1
A25R33		Same as A25R13		
A25R34		Same as A25R19		
A25R35		Same as A25R3		
A25R36		Same as A25R1		
A25R37		Same as A25R7		
A25R38		Same as A25R3		
A25R39 & A25R40		Same as A25R1		
A25R41 & A25R42		Same as A25R11		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A25R43 & A25R44		Same as A25R13		
A25R45 & A25R46		Same as A25R1		
A25R47		Same as A25R15		
	864-412958	Transistor Pads, Mounting	B/B	13
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A26	887-422376	F Logic	B/B	1
A26C1	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	4
A26C6	637-824010	Capacitor, F. Mica, 33pf, 300V, 5%	Electromotive DM16E-300J-300	2
A26C8		Same as A26C6		
A26C12		Same as A26C1		
A26C14		Same as A26C1		
A26C15		Same as A26C1		
A26CR2	755-815561	Diode, Silicon, 75PIV, 10ma, 1V min. fwd.	Continental CD6111	4
A26CR3 & A26CR4		Same as A26CR2		
A26CR8	755-402107	Diode, Special	B/B	1
A26CR10		Same as A26CR2		
A26CR14	755-817812	Diode, Germanium, 15PIV, 100 ma	Clevite CGD-1092	1
A26R4	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	Allen Bradley CB1531	3
A26R6 & A26R7		Same as A26R4		
A26R10	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	Allen Bradley CB1521	1
A26R13	601-823923	Resistor, F. Comp., 33Ω, 1/4W, 10%	Allen Bradley CB3301	2
A26R14		Same as A26R13		
		* * * * * * * * * * * * * * * * * * * *		
A28	887-410903	Control	B/B	1
A28C1	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	4
A28C2	637-824016	Capacitor, F. Mica, 100pf, 300V, 5%	Arco DM16E101J-300	1
A28C3	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	Arco DM16C220J-300	4
A28C4		Same as A28C1		
A28C5		Same as A28C3		
A28C6		Same as A28C1		
A28C7	637-824012	Capacitor, F. Mica, 47pf, 300V, 5%	Arco DM16E470J-300	1
A28C8 & A28C9		Same as A28C3		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A28C10		Same as A28C1		
A28CR1	755-815561	Diode, Silicon, 75PIV, 10ma, 1V min. fwd.	Continental CD6111	7
A28CR2 thru A28CR5		Same as A28CR1		
A28CR6	755-824300	Diode, Germanium	Hughes HD1842	4
A28CR7		Same as A28CR6		
A28CR8 & A28CR9		Same as A28CR1		
A28CR10 & A28CR11		Same as A28CR6		
A28Q1	755-817811	Transistor, Germanium, PNP, 150mw	Motorola 2N961	7
A28Q2		Same as A28Q1		
A28Q3	755-419596	Transistor, Special	B/B	1
A28Q4 thru A28Q9		Same as A28Q1		
A28R1	601-008068	Resistor, F. Comp., 180Ω, 1/2W, 10%	Allen Bradley EB1811	3
A28R2		Same as A28R1		
A28R3	601-823921	Resistor, F. Comp., 22Ω, 1/4W, 10%	Allen Bradley CB2201	1
A28R4	601-823395	Resistor, F. Comp., 470Ω, 1/4W, 5%	Allen Bradley CB4715	1
A28R5	601-823944	Resistor, F. Comp., 5.6K, 1/4W, 10%	Allen Bradley CB5621	2
A28R6		Same as A28R1		
A28R7	601-823108	Resistor, F. Comp., 10K, 1/4W, 10%	Allen Bradley CB1031	2
A28R8	601-823945	Resistor, F. Comp., 6.8K, 1/4W, 10%	Allen Bradley CB6821	3
A28R9	601-823946	Resistor, F. Comp., 8.2K, 1/4W, 10%	Allen Bradley CB8221	2
A28R10	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	Allen Bradley CB1531	6
A28R11		Same as A28R9		
A28R12	601-823111	Resistor, F. Comp., 1K, 1/4W, 10%	Allen Bradley CB1021	5
A28R13	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	Allen Bradley CB1521	1
A28R14		Same as A28R8		
A28R15		Same as A28R10		
A28R16	601-822397	Resistor, F. Comp., 5.6K, 1/4W, 5%	Allen Bradley CB5625	4
A28R17		Same as A28R12		
A28R18		Same as A28R16		
A28R19		Same as A28R10		
A28R20	601-823934	Resistor, F. Comp., 270Ω, 1/4W, 10%	Allen Bradley CB2711	2
A28R21		Same as A28R12		
A28R22		Same as A28R7		
A28R23		Same as A28R5		
A28R24		Same as A28R16		
A28R25		Same as A28R10		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A28R26		Same as A28R12		
A28R27		Same as A28R16		
A28R28		Same as A28R10		
A28R29		Same as A28R20		
A28R30		Same as A28R12		
A28R31		Same as A28R8		
A28R32		Same as A28R10		
	864-412958	Pad, Connector, Transistor	B/B	8
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A30	887-422422	Time Base Logic	B/B	1
A30C1	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	2
A30C2	637-824018	Capacitor, F. Mica, 150pf, 300V, 5%	Electromotive DM16E-151J-300	6
A30C3	637-824020	Capacitor, F. Mica, 220pf, 300V, 5%	Electromotive DM16E-221J-300	1
A30C4 thru A30C6		Same as A30C2		
A30C7		Same as A30C1		
A30C8 & A30C9		Same as A30C2		
A30C10	637-824012	Capacitor, F. Mica, 47pf, 300V, 5%	Electromotive DM16E-470J-300	1
A30CR1	755-402107	Diode, Special	B/B	7
A30CR2		Same as A30CR1		
A30CR3	755-824300	Diode, Germanium	Hughes HD1842	2
A30CR4 & A30CR5		Same as A30CR1		
A30CR6		Same as A30CR3		
A30CR7 thru A30CR8 & A30CR9		Same as A30CR1		
A30Q1	755-817811	Transistor, Germanium, PNP, 150mw	Motorola 2N961	3
A30Q2		Same as A30Q1		
A30Q4		Same as A30Q1		
A30R1	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	Allen Bradley CB1531	7
A30R2	601-815239	Resistor, F. Comp., 4.7K, 1/4W, 10%	Allen Bradley CB4721	7
A30R3	601-823104	Resistor, F. Comp., 390Ω, 1/4W, 10%	Allen Bradley CB3911	2
A30R4	601-822296	Resistor, F. Comp., 3.3K, 1/4W, 5%	Allen Bradley CB3325	1
A30R5		Same as A30R1		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A30R6		Same as A30R2		
A30R7	601-822299	Resistor, F. Comp., 6.8K, 1/4W, 5%	Allen Bradley CB6825	1
A30R8		Same as A30R2		
A30R9	601-823937	Resistor, F. Comp., 680Ω, 1/4W, 10%	Allen Bradley CB6811	2
A30R10		Same as A30R1		
A30R11		Same as A30R2		
A30R12		Same as A30R1		
A30R13		Same as A30R9		
A30R14	601-823942	Resistor, F. Comp., 3.3K, 1/4W, 10%	Allen Bradley CB3321	1
A30R15		Same as A30R1		
A30R16		Same as A30R2		
A30R17		Same as A30R1		
A30R18		Same as A30R2		
A30R19		Same as A30R1		
A30R20		Same as A30R2		
A30R27	601-823925	Resistor, F. Comp., 47Ω, 1/4W, 10%	Allen Bradley CB4701	1
A30R28		Same as A30R3		
A30R29	601-822370	Resistor, F. Comp., 510Ω, 1/4W, 5%	Allen Bradley CB5115	1

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A31	887~~-412605~~ 424126 (Orec Schem #)	1 - 10 Mc Multiplier	B/B	1
A31C1	639-007467	Capacitor, F. Paper, 0.1μf, 400V, 20%	Hopkins P14D	1
A31C2	633-811290	Capacitor, F. Cerm., 47pf, 600V	Skottie TCD-6-NPO	2
A31C3		Same as A31C2		
A31C4	633-824213	Capacitor, F. Cerm., 2.2pf, 600V, 10%	Skottie TCD-4-NPO	1
A31C5	637-824010	Capacitor, F. Mica, 33pf, 300V, 5%	Arco DM16E330J-300	1
A31C6	633-811287	Capacitor, F. Cerm., 6.8pf, 600V, 10%	Skottie TCD-4-NPO	1
A31C7	637-824017	Capacitor, F. Mica, 120pf, 300V, 5%	Arco DM16E121J-300	1
A31C8	637-824024	Capacitor, F. Mica, 470pf, 300V, 5%	Arco DM16E471J-300	1
A31C9	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	3
A31C10 & A31C11		Same as A31C9		
A31CR1	755-409096	Diode, Type, 1N198, w/Point Contact	B/B	2
A31CR2		Same as A31CR1		
A31L1	792-411964	Inductor B/B	1	
A31L2	792-411965	Inductor B/B	1	
A31Q1	755-419596	Transistor, Special	B/B	1
A31R1	601-822327	Resistor, F. Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	1
A31R2	601-822328	Resistor, F. Comp., 2.2K, 1/4W, 5%	Allen Bradley CB2225	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A31R3	601-823371	Resistor, F. Comp., 390Ω, 1/4W, 5%	Allen Bradley CB3915	2
A31R4		Same as A31R3		
A31R5	601-823395	Resistor, F. Comp., 470Ω, 1/4W, 5%	Allen Bradley CB4715	1
	864-412958	Pad, Connector, Transistor	B/B	1
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A32	887-422431	Legend	B/B	1
A32C1	637-824020	Capacitor, F. Mica, 220pf, 300V, 5%	Electromotive DM16E-221J-300	2
A32C2	631-814053	Capacitor, F. Elect., 1μf, 35V, 20%	Sprague 150D105X0035A2	1
A32C3	633-804717	Capacitor, F. Cerm., 0.01μf, 500C	Sprague 29C9B5	1
A32C4		Same as A32C1		
A32CR5	755-404593	Diode, Special	B/B	1
A32DS3	825-414955	Lamp, Neon, Special	B/B	2
A32DS4		Same as A32DS3		
A32Q1	755-800398	Transistor, Germanium, PNP, 150mw max.	Sylvania 2N404	2
A32Q2		Same as A32Q1		
A32Q3	755-410066	Transistor, Special	B/B	1
A32Q4	755-817964	Transistor, Silicon, NPN, 600mw, max.	P.S.I. 2N1420	1
A32R3	601-822337	Resistor, F. Comp., 91K, 1/4W, 5%	Allen Bradley CB9135	2
A32R4		Same as A32R3		
A32R9	601-824831	Resistor, F. Comp., 2.2M, 1/4W, 10%	Allen Bradley CB2251	2
A32R10		Same as A32R9		
A32R15	601-823951	Resistor, F. Comp., 47K, 1/4W, 10%	Allen Bradley CB4731	2
A32R16		Same as A32R15		
A32R19	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	Allen Bradley CB1521	3
A32R20	601-822334	Resistor, F. Comp., 22K, 1/4W, 5%	Allen Bradley CB2235	1
A32R21		Same as A32R19		
A32R22	601-823944	Resistor, F. Comp., 5.6K, 1/4W, 10%	Allen Bradley CB5621	1
A32R4	601-823110	Resistor, F. Comp., 22K, 1/4W, 10%	Allen Bradley CB2231	1
A32R25	601-822324	Resistor, F. Comp., 10K, 1/4W, 5%	Allen Bradley CB1035	1
A32R26	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	Allen Bradley CB1531	2
A32R27	601-823109	Resistor, F. Comp., 33K, 1/4W, 10%	Allen Bradley CB3331	1
A32R28	601-815239	Resistor, F. Comp., 4.7K, 1/4W, 10%	Allen Bradley CB4721	2
A32R29	601-823954	Resistor, F. Comp., 82K, 1/4W, 10%	Allen Bradley CB8231	1
A32R30	601-823945	Resistor, F. Comp., 6.8K, 1/4W, 10%	Allen Bradley CB6821	2
A32R31		Same as A32R30		
A32R32	601-823948	Resistor, F. Comp., 18K, 1/4W, 10%	Allen Bradley CB1831	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A32R33		Same as A32R19		
A32R34		Same as A32R28		
A32R35		Same as A32R26		
A32V3	753-416278	Photo-Resistor, End View, Special	B/B	2
A32V4		Same as A32V3		
	864-412958	Transistor Pad	B/B	6
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A33	887-411673	Recycle	B/B	1
A33C1	637-824020	Capacitor, F. Mica, 220pf, 300V, 5%	Arco DM16E221J-300	17
A33C2	637-824024	Capacitor, F. Mica, 470pf, 300V, 5%	Arco DM16E471J-300	4
A33C3		Same as A33C2		
A33C4 & A33C5		Same as A33C1		
A33C6	637-824022	Capacitor, F. Mica, 330pf, 300V, 5%	Arco DM16E331J-300	1
A33C7 & A33C8		Same as A33C1		
A33C9		Same as A33C2		
A33C10	631-819463	Capacitor, F. Elect., 3.3μf, 15V, 10%	Fansteel STA5123-1	1
A33C11	637-824018	Capacitor, F. Mica, 150pf, 300V, 5%	Arco DM16E151J-300	2
A33C12 & A33C13		Same as A33C1		
A33C14	637-824027	Capacitor, F. Mica, 820pf, 300V, 5%	Arco DM16E821J-300	1
A33C15		Same as A33C2		
A33C16		Same as A33C1		
A33C17	631-828102	Capacitor, F. Elect., 4.7μf, 100V	Fansteel SP120-11	1
A33C18	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	4
A33C19 thru A33C23		Same as A33C1		
A33C24		Same as A33C18		
A33C25		Same as A33C1		
A33C26		Same as A33C11		
A33C27		Same as A33C1		
A33C28		Same as A33C18		
A33C29		Same as A33C1		
A33C30	631-814053	Capacitor, F. Elect., 1μf, 35V, 20%	Sprague 150D105X0035A2	1
A33C31		Same as A33C1		
A33C32		Same as A33C18		
A33CR1	755-404593	Diode, Special	B/B	27

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A33CR2 thru A33CR5		Same as A33CR1		
A33CR6	755-402107	Diode, Special	B/B	3
A33CR7 thru A33CR13		Same as A33CR1		
A33CR14		Same as A33CR6		
A33CR15 thru A33CR21		Same as A33CR1		
A33CR22		Same as A33CR6		
A33CR23 thru A33CR30		Same as A33CR1		
A33DS1	825-414955	Lamp, Neon, Special	B/B	1
A33Q1	755-800398	Transistor, Germanium, PNP, 150mw max.	Sylvania 2N404	23
A33Q2 thru A33Q12		Same as A33Q1		
A33Q13	755-410066	Transistor, Special	B/B	1
A33Q14 thru A33Q24		Same as A33Q1		
A33R1	601-823949	Resistor, F. Comp., 27K, 1/4W, 10%	Allen Bradley CB2731	1
A33R2	601-823942	Resistor, F. Comp., 3.3K, 1/4W, 10%	Allen Bradley CB3321	10
A33R3	601-823948	Resistor, F. Comp., 18K, 1/4W, 10%	Allen Bradley CB1831	2
A33R4	601-823944	Resistor, F. Comp., 5.6K, 1/4W, 10%	Allen Bradley CB5621	2
A33R5	601-823109	Resistor, F. Comp., 33K, 1/4W, 10%	Allen Bradley CB3331	7
A33R6	601-823108	Resistor, F. Comp., 10K, 1/4W, 10%	Allen Bradley CB1031	13
A33R7		Same as A33R2		
A33R8	601-822334	Resistor, F. Comp., 22K, 1/4W, 5%	Allen Bradley CB2235	6
A33R9	601-823933	Resistor, F. Comp., 220Ω, 1/4W, 10%	Allen Bradley CB2211	2
A33R10	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	Allen Bradley CB1531	3
A33R11	601-823951	Resistor, F. Comp., 47K, 1/4W, 10%	Allen Bradley CB4731	2
A33R12		Same as A33R2		
A33R13 thru A33R15		Same as A33R6		
A33R16	601-823110	Resistor, F. Comp., 22K, 1/4W, 10%	Allen Bradley CB2231	8
A33R17	601-822324	Resistor, F. Comp., 10K, 1/4W, 5%	Allen Bradley CB1035	5
A33R18	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	Allen Bradley CB1521	13
A33R19		Same as A33R8		
A33R20		Same as A33R18		
A33R21	601-823931	Resistor, F. Comp., 150Ω, 1/4W, 10%	Allen Bradley CB1511	2

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A33R22		Same as A33R18		
A33R23		Same as A33R6		
A33R24		Same as A33R17		
A33R25		Same as A33R16		
A33R26		Same as A33R18		
A33R27		Same as A33R8		
A33R28		Same as A33R18		
A33R29		Same as A33R5		
A33R30		Same as A33R10		
A33R31		Same as A33R5		
A33R32		Same as A33R2		
A33R33		Same as A33R17		
A33R34		Same as A33R16		
A33R35		Same as A33R18		
A33R36		Same as A33R8		
A33R37		Same as A33R6		
A33R38		Same as A33R18		
A33R39	601-823923	Resistor, F. Comp., 33Ω, 1/4W, 10%	Allen Bradley CB3301	1
A33R40		Same as A33R18		
A33R41		Same as A33R3		
A33R42		Same as A33R4		
A33R43		Same as A33R5		
A33R44		Same as A33R2		
A33R45		Same as A33R8		
A33R46		Same as A33R9		
A33R47		Same as A33R11		
A33R48 & A33R49		Same as A33R2		
A33R50		Same as A33R6		
A33R51	601-823945	Resistor, F. Comp., 6.8K, 1/4W, 10%	Allen Bradley CB6821	2
A33R52		Same as A33R16		
A33R53	601-815239	Resistor, F. Comp., 4.7K, 1/4W, 10%	Allen Bradley CB4721	1
A33R54	601-812856	Resistor, F. Comp., 2.2K, 1/4W, 10%	Allen Bradley CB2221	1
A33R55	601-823944	Resistor, F. Comp., 5.6K, 1/4W, 5%	Allen Bradley CB5625	1
A33R56	601-015053	Resistor, F. Comp., 10K, 2W, 5%	Allen Bradley HB1035	1
A33R57 & A33R58		Same as A33R5		
A33R59	601-823947	Resistor, F. Comp., 12K, 1/4W, 10%	Allen Bradley CB1231	1
A33R60		Same as A33R2		
A33R61		Same as A33R6		
A33R62	601-822333	Resistor, F. Comp., 12K, 1/4W, 5%	Allen Bradley CB1235	1
A33R63		Same as A33R5		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty. / Ass'y
A33R64		Same as A33R2		
A33R65 thru A33R67		Same as A33R6		
A33R68		Same as A33R17		
A33R69		Same as A33R16		
A33R70		Same as A33R18		
A33R71		Same as A33R8		
A33R72		Same as A33R18		
A33R73		Same as A33R21		
A33R74		Same as A33R18		
A33R75		Same as A33R16		
A33R76		Same as A33R17		
A33R77		Same as A33R18		
A33R78		Same as A33R16		
A33R79	601-823929	Resistor, F. Comp., 100Ω, 1/4W, 10%	Allen Bradley CB1011	2
A33R80		Same as A33R18		
A33R81		Same as A33R6		
A33R82	601-812742	Resistor, F. Comp., 220K, 1/4W, 10%	Allen Bradley CB2241	1
A33R83		Same as A33R79		
A33R84		Same as A33R6		
A33R85		Same as A33R2		
A33R86		Same as A33R51		
A33R87		Same as A33R16		
A33R88		Same as A33R10		
A33R89	601-800011	Resistor, F. Comp., 270Ω, 1/2W, 5%	Allen Bradley EB2735	1
	864-412958	Pad, Converter Transistor	B/B	24

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A34	887-412442	Regulator	B/B	1
A34C1	631-814053	Capacitor, F. Elect., 1μf, 35V, 20%	Sprague 150D105X0035A2	2
A34C2		Same as A34C1		
A34CR1	755-404593	Diode, Silicon, Special	B/B	2
A34CR2	755-824951	Diode, Zener, 400mw	Motorola 1N754	2
A34CR3		Same as A34CR1		
A34CR4		Same as A34CR2		
A34Q1	755-811274	Transistor, Type 2N445A	Gen. Trans.	2
A34Q2	755-800398	Transistor, Germanium, PNP, 150mw max.	Sylvania 2N404	4
A34Q3		Same as A34Q2		
A34Q4		Same as A34Q1		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A34Q5 & A34Q6		Same as A34Q2		
A34Q7	755-415078	Transistor, Special	B/B	1
A34R1	601-823934	Resistor, F. Comp., 270Ω, 1/4W, 10%	Allen Bradley CB2711	2
A34R2	601-008065	Resistor, F. Comp., 100Ω, 1/2W, 10%	Allen Bradley EB1011	1
A34R3	601-823104	Resistor, F. Comp., 390Ω, 1/4W, 10%	Allen Bradley CB3911	2
A34R4	601-823105	Resistor, F. Comp., 470Ω, 1/4W, 10%	Allen Bradley CB4711	2
A34R5	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	Allen Bradley CB1521	1
A34R6	601-008059	Resistor, F. Comp., 2.2K, 1W, 10%	Allen Bradley GB2221	2
A34R7	601-815239	Resistor, F. Comp., 4.7K, 1/4W, 10%	Allen Bradley CB4721	2
A34R8	611-812861	Resistor, V., W. W., 220Ω, 1.5W, 20%	C.T.S. Series 111	2
A34R9	601-008071	Resistor, F. Comp., 330Ω, 1/2W, 10%	Allen Bradley EB3311	2
A34R10		Same as A34R1		
A34R11	601-008068	Resistor, F. Comp., 180Ω, 1/2W, 10%	Allen Bradley EB1811	1
A34R12		Same as A34R4		
A34R13		Same as A34R3		
A34R14		Same as A34R8		
A34R15		Same as A34R6		
A34R16		Same as A34R7		
A34R17		Same as A34R9		
A34R18	601-812856	Resistor, F. Comp., 2.2K, 1/4W, 10%	Allen Bradley CB2221	1
A34R19	601-800143	Resistor, F. Comp., 3.3K, 2W, 5%	Allen Bradley EB3325	1
A34R20	601-822296	Resistor, F. Comp., 3.3K, 1/4W, 5%	Allen Bradley CB3321	1
A34R21	601-812860	Resistor, V., W.W., 2000Ω, 1.5W, 20%	C.T.S. Series 111	1
A34R22	601-016229	Resistor, F. Comp., 1.5K, 1W, 5%	Allen Bradley GB1525	1
A34R23	601-800132	Resistor, F. Comp., 680Ω, 2W, 5%	Allen Bradley GB6811	1
A34R24	601-043215	Resistor, F. Comp., 18K, 1W, 5%	Allen Bradley GB1835	1
	864-412958	Pad, Converter, Transistor	B/B	6
		* *		
A35	887-412795	E.L. Supply	B/B	1
A35C1	631-824631	Capacitor, F. Elect., 10μf, 20V, 20%	Fansteel STA-621-1	1
A35C2	631-802980	Capacitor, F. Elect., 22μf, 25V, 20%	Sprague 109D226X-0025C2	1
A35C3	631-828130	Capacitor, F. Elect., 150μf, 15V, 10%	Fansteel STA806-1	1
A35Q1	755-824875	Transistor, Germanium, PNP, 63W	Motorola 2N2139	2
A35Q2		Same as A35Q1		
A35Q3	755-800398	Transistor, Germanium, PNP, 150mw max.	Sylvania 2N404	2
A35Q4		Same as A35Q3		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A35R1	601-800031	Resistor, F. Comp., 470Ω, 1/2W, 10%	Allen Bradley EB4711	2
A35R2	601-823917	Resistor, F. Comp., 10Ω, 1/4W, 10%	Allen Bradley CB1001	1
A35R3		Same as A35R1		
A35R4	611-812861	Resistor, V. W.W., 200Ω, 1.5W, 20%	C.T.S. Series 111	1
A35R5	601-008071	Resistor, F. Comp., 330Ω, 1/2W, 10%	Allen Bradley EB3311	1
A35R6	601-008068	Resistor, F. Comp., 180Ω, 1/2W, 10%	Allen Bradley EB1811	1
A35R7	601-010684	Resistor, F. Comp., 3.3K, 1/2W, 10%	Allen Bradley EB3321	1
A35R8	601-007932	Resistor, F. Comp., 10K, 1/2W, 10%	Allen Bradley EB1031	1
A35R9	601-823935	Resistor, F. Comp., 330Ω, 1/4W, 10%	Allen Bradley CB3311	1
A35R10	604-819969	Resistor, F. W.W., 1.5Ω, 1/2W, 5%	I.R.C. BW	1
	864-412958	Pad, Transistor	B/B	2
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A43	887-411676	1 Mc Oscillator	B/B	1
A43C1	631-814053	Capacitor, F. Elect., 1μf, 35V, 20%	Sprague 150D105X-0035A2	1
A43C2	631-802980	Capacitor, F. Elect., 22μf, 25V, 20%	Sprague 109D226X-0025C2	1
A43C3	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	Sprague 29C9B5	2
A43C4		Same as A43C3		
A43C5	637-824018	Capacitor, F. Mica, 150pf, 300V, 5%	Arco DM16E151J-300	1
A43C6	637-824302	Capacitor, F. Mica, 300pf, 300V, 5%	Arco DM16E301J-300	1
A43C7	637-824028	Capacitor, F. Mica, 1000pf, 300V, 5%	Arco DM16E102J-300	1
A43C8	637-824301	Capacitor, F. Mica, 2000pf, 300V, 5%	Arco DM20F202-300	2
A43C9	637-824025	Capacitor, F. Mica, 560pf, 300V, 5%	Arco DM16E561J-300	2
A43C10		Same as A43C9		
A43C11		Same as A43C8		
A43C12	637-824303	Capacitor, F. Mica, 3900pf, 300V, 5%	Arco DM20F392-300	1
A43CR1	755-811280	Diode, Ref., Sil., 5V min., 5.5V max.	Cont. Device CD3319	1
A43CR2	755-402107	Diode, Special	B/B	1
A43L1	795-807904	Inductor, Fixed, R.F., 0.100mh	National RA-100-P	1
A43L2	795-827337	Inductor, Fixed, R.F., 0.0068mh	National NB6.8I	1
A43Q1	755-817216	Transistor, Germanium, PNP, 75mw max.	Philco 2N502A	2
A43Q2		Same as A43Q1		
A43Q3	755-817811	Transistor, Germanium, PNP, 150mw	Motorola 2N961	2
A43Q4		Same as A43Q3		
A43Q5	755-823113	Transistor, Silicon, NPN, 800mw max.	Motorola 2N2219	1
A43R1	601-822327	Resistor, F. Comp., 220Ω, 1/4W, 5%	Allen Bradley CB2215	1
A43R2	601-015446	Resistor, F. Comp., 470Ω, 1/2W, 5%	Allen Bradley EB4715	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
A43R3	601-822460	Resistor, F. Comp., 3.9K, 1/4W, 5%	Allen Bradley CB3925	2
A43R4	601-822299	Resistor, F. Comp., 6.8K, 1/4W, 5%	Allen Bradley CB6825	1
A43R5	601-822333	Resistor, F. Comp., 12K, 1/4W, 5%	Allen Bradley CB1235	1
A43R6	601-822306	Resistor, F. Comp., 820Ω, 1/4W, 5%	Allen Bradley CB8215	2
A43R7	601-822295	Resistor, F. Comp., 2.7K, 1/4W, 5%	Allen Bradley CB2725	2
A43R8		Same as A43R6		
A43R9		Same as A43R3		
A43R10	601-822308	Resistor, F. Comp., 1K, 1/4W, 5%	Allen Bradley CB1025	2
A43R11	611-812859	Resistor, V. W.W., 5K, 1.5W, 20%	C. T.S. Series 111	1
A43R12		Same as A43R7		
A43R13	601-822328	Resistor, F. Comp., 2.2K, 1/4W, 5%	Allen Bradley CB2225	1
A43R14		Same as A43R10		
A43R15	601-822544	Resistor, F. Comp., 1.8K, 1/4W, 5%	Allen Bradley CB1825	1
A43R16	601-817735	Resistor, F. Comp., 100Ω, 1/4W, 5%	Allen Bradley CB1015	1
A43R17	601-822326	Resistor, F. Comp., 1.2K, 1/4W, 5%	Allen Bradley CB1225	1
A43R18	601-822306	Resistor, F. Comp., 820Ω, 1/4W, 5%	Allen Bradley CB8215	2
A43R19		Same as A43R18		
	864-412958	Pad, Converter, Transistor	B/B	5
The following components are associated with Board A38:				
C1	655-415515	Capacitor, V. Glass, 0.6-14pf, 1000V PPM/^{o}C, -40 to +50	J. F. D. Elect. VC11-GRA (Mod)	1
C2		Factory Selected Value		
C3	633-827603	Capacitor, F. Cerm., 3.3pf, T. C. -750 PPM/^{o}C	Centralab TCN-3R3	1
L1	795-807919	Inductor, F. RF, 0.470mh, 9Ω, 285ma	Delevan 3500-24	2
L2		Same as L1		
XA43	680-824871	P. C. Connector, 15 Contacts	Cinch 250-15-70-170	1
XY1	860-802333	Socket, Tube, 8-Pin, Saddle Mounting	Cinch 16203	1
Y1	881-412796	Crystal and Oven Assembly	B/B	1
	327-409643	P. C. Board Support	B/B	2
	430-415714	Assembly Rivet, Oscillator Chassis	B/B	1
	430-415711	Chassis Oscillator	B/B	1
	327-404468	P. C. Board Support, Finish	B/B	2
	327-415710	Bracket, Oven Clamp	B/B	1
	864-415712	Insulator, Oven Clamp Bracket	B/B	1
	327-415709	Bracket, Trimmer	B/B	1
		* *		
	887-421410	Model 696 Basic Plug-In	B/B	1
P6	672-824945	Connector, Plug, Male, 50 Contacts	Amphenol 57-10500	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty. / Ass'y
XA1-1	680-824115	Connector, P.C., 15 Dual Contacts	Cinch 251-15-70-160	2
XA1-2		Same as XA1-1		
	261-413417	Emblem, Trademark	B/B	1
	338-414713	Accessory Holder, Blank Plug-In	B/B	1
	338-414714	Spacer, Blank Plug-In	B/B	1
	433-413322	Panel, Rear	B/B	1
	449-413463	Assembly, Securing Rod	B/B	1
	139-413460	Rod, Securing	B/B	1
	325-413461	Knob, Securing Rod	B/B	1
	433-413842	Weld Assembly, Panel	B/B	1
	449-413265	Weld Tab	B/B	4
	433-413841	Panel, Front	B/B	1
	449-413221	Bracket Handle Assembly, Left	B/B	1
	330-413219	Handle	B/B	2
	327-413220	Rack Mounting Bracket, Left	B/B	1
	449-413325	Bracket Handle Assembly, Right	B/B	1
	327-413227	Rack Mounting, Bracket, Right	B/B	1
	349-413318	Side Plate, Right	B/B	1
	349-413319	Side Plate, Left	B/B	1
	297-413584	Dust Cover	B/B	2
	858-411920	Extension Board	B/B	2

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The following components may be found in Figures 2-1, 2-2, and 4-3:

C1	631-412828	Capacitor, F. Elect., 1500μf, 30V	B/B	3
C2 & C3				
C4	631-410854	Capacitor, F. Elect., 300μf, 150V	B/B	1
C5	639-835127	Capacitor, F. Paper, 3μf, 50V, 10%	Elpac VX5A305K	1
C7	633-804718	Capacitor, F. Cerm., 0.01μf, 600V	Erie 811-.01	
C8	651-827327	Capacitor, F. Mylar, 1μf, 600V	Elpac ZX-7-P-105	1
CR1	774-824971	Rectifier Bridge, 3 Amps	Semtech SA780	1
CR2	774-824972	Rectifier Bridge, 1.5 Amps	Semtech SCBR2	2
CR3		Same as CR2		
DS1	824-824973	Lamp, Neon, Plug-in Cartridge	Eldema CG3-CC-A1B	1
DS2	823-412941	Readout, EL, Eight Digit	B/B	1
E1	778-413840	Amplifier Shield	B/B	1
F1	731-801567	Fuse, Electrical, 1.5 Amp, 150V, T.D.	Littelfuse 31301.5	1
J1	670-806738	Connector, Coaxial, Receptacle. BNC Type	Amphenol UG-1094/U	3
J3 & J4		Same as J1		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
J5	683-817991	Jack, Banana, Red Nylon	Johnson 108-902	1
J6 & J7	672-824946	Connector, Receptacle, 50 Female Contacts	Amphenol 57-20500	2
K1	718-827701	Relay, 12V, 4 Form C	Potter-Brm. KHP 17D12	1
Q1	755-822107	Transistor, Germ., PNP, 2ma, Xax	Motorola 2N1544	3
Q2 & Q3		Same as Q1		
Q4	755-415078	Transistor, Special	B/B	1
R1	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	Allen Bradley CB1521	1
R2	604-801990	Resistor, F. W.W., 10Ω, 5W, 10%	Tru-Ohm FRL-5-10-10%	1
R3	601-822371	Resistor, F. Comp., 390Ω, 1/4W, 5%	Allen Bradley CB3915	1
R8	601-800132	Resistor, F. Comp., 680Ω, 2W, 5%	Allen Bradley HB6815	1
R9 & R10	601-000899	Resistor, F. Comp., 4.7K, 1/2W, 5%	Allen Bradley EB4725	2
R11	601-823111	Resistor, F. Comp., 1K, 1/4W, 10%	Allen Bradley CB1021	1
R12	614-806316	Resistor, V. Comp., 2.5K, 2W, 10%	Allen Bradley JA1N0 48S252UZ	1
S1	711-806125	Switch, Rotary, 2 Pole, 5 Positions	Centralab PA1003	1
S2	711-806119	Switch, Rotary, 2 Pole, 6 Positions	Centralab PA2003	1
S5	711-422427	Switch, Power	B/B	1
S6	716-827410	Switch, Slide, DPDT	Continental Type 126 (C-W)	1
T1	792-411294	Transformer, Power	B/B	1
T2	792-411415	Transformer, EL	B/B	1
XA1	680-824871	Connector, Printed Circuit, 15 Contacts	Cinch 250-15-30-170	38
XA2A & XA2B		Same as XA1		
XA3		Same as XA1		
XA4A & XA4B		Same as XA1		
XA5		Same as XA1		
XA6A & XA6B		Same as XA1		
XA7		Same as XA1		
XA8A & XA8B		Same as XA1		
XA9		Same as XA1		
XA10A & XA10B		Same as XA1		
XA11		Same as XA1		
XA12A & XA12B		Same as XA1		
XA13		Same as XA1		
XA14A & XA14B		Same as XA1		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
XA15		Same as XA1		
XA16A & XA16B		Same as XA1		
XA17 & XA18		Same as XA1		
XA21		Same as XA1		
XA23		Same as XA1		
XA25		Same as XA1		
XA26	680-824115	Connector, Printed Circuit, 15 Contacts	Cinch 251-15-30-160	2
XA28		Same as XA1		
XA30		Same as XA26		
XA31		Same as XA1		
XA32A & XA32B		Same as XA1		
XA33A & XA33B		Same as XA1		
XA34 & XA35		Same as XA1		
XDS1	824-824974	Socket, Lamp Cartridge Mounting	Eldema #2K	1
XDS2	697-412938	Socket, 8 Digit Electroluminescent Panel	B/B	1
XE1		Same as XA1		
XF1	735-007268	Fuseholder, 15 Amp, at 250 Breakdown	Bussman HKP	1
XK1	860-824956	Socket, Relay	Potter-Brm. 27E003	1
Z1	771-416479	Filter, Interference	B/B	1
	132-824977	Clip, Retainer, Indicator	Eldema 10905-01	1
	664-812450	Cordset, Elect., Power, 3 Cond., Blk., 6 Ft.	B/B	1
	261-415937	Emblem	B/B	1
	325-413171	Knob, Round, Skirted	B/B	2
	325-415351	Knob, Power	B/B	1
	325-415335	Knob, Display	B/B	1
	433-411659	Front Panel	B/B	1
	783-807862	Ferrite Bead	Ferroxcube 56-590-65/ 3B	1
	105-827409	Nut, Anchor 1/4 - 20, Steel Cad. Plated	Tinnerman C7956-1420	1
	349-413691	Retainer, Top Cover	B/B	1
	405-415007	Right Guide, Top Cover	B/B	1
	405-415006	Left Guide, Top Cover	B/B	1
	297-413615	Top Cover	B/B	1
	449-413695	Top Cover Weld Assembly	B/B	1
	716-413516	Reset Button	B/B	1
	327-413153	Bracket, Plug-In	B/B	1

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
	405-413714	Pin, Guide	B/B	1
	778-412944	EL Shield	B/B	1
	297-413696	Bottom Dust Cover	B/B	1
	693-422134	Printed Circuit Safety Shield Board	B/B	1
	139-015124	Shaft Lock, Brass Nickel, Plated	USECO 1510	1
	842-819209	Fan Motor	Howard 1075-3202	1
	776-411321	Heat Sink	B/B	1
	776-827328	Heat Sink	Augut 9015-1G1	1
	864-806361	Insulator, Transistor Mtg., Aluminum	Monadnock 294457	2
	430-411658	Main Chassis	B/B	1
	330-413694	Handle, Cast	B/B	1
	695-807399	Terminals, Insulated, #4-40 Thd.	Armel TT-12	2
	449-413115	Screen Weld Assembly	B/B	1
	337-413108	Fan Guard	B/B	1
	408-413111	Screen	B/B	1
	433-413055	Rear Panel	B/B	1
	348-422798	Plate, Capacitor & Trigger	B/B	1
	430-413099	Power Supply Chassis	B/B	1
	348-414957	Cover Plate, Connector	B/B	2
	327-404468	Printed Circuit Board Support	B/B	4
	338-421883	Clamp, Filter	B/B	1
	327-414796	Modification, P.C. Board Holder	B/B	8
	349-414969	Tilt Foot	B/B	1
	338-414685	Spring Clamp, Tilt Foot	B/B	2
	348-414684	Detent Plate, Tilt Foot	B/B	2
	349-414683	Locking Plate, Tilt Foot	B/B	2
	302-413690	Spring Detent, Tilt Foot	B/B	2
	125-415249	Hinge Pin, Tilt Foot	B/B	2
	302-413692	Spring, Handle	B/B	2
	327-414710	Modified P.C. Board Holder	B/B	2
	662-414797	Power Supply Cable	B/B	1
	662-422530	Cable, EL	B/B	1
	662-422537	Cable, Main Chassis	B/B	1

MODIFICATION A1

Modification A1 provides a digital recorder output connector at the rear of the instrument. This multi-terminal socket, wired to the readout lines of each storage binary, makes available 1-2-4-8 binary-coded signals for use with such auxiliary equipment as printers, display units, and data converters.

MODIFICATION A2

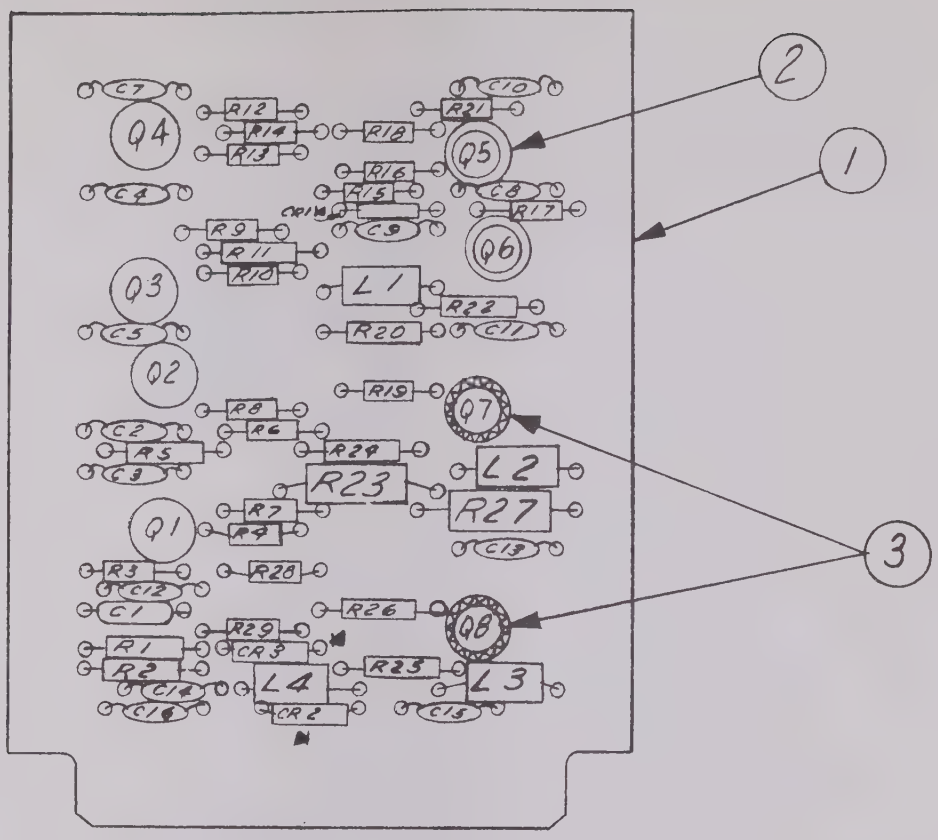
Instruments with this modification have a 10 second time base position on the TIME selector. Addition of a Model 850 Decimal Counting Unit to the time base divider chain provides this 10 second time base.

MODIFICATION A3

One additional digit of visual, storage, and readout BCD capability is provided with this modification.

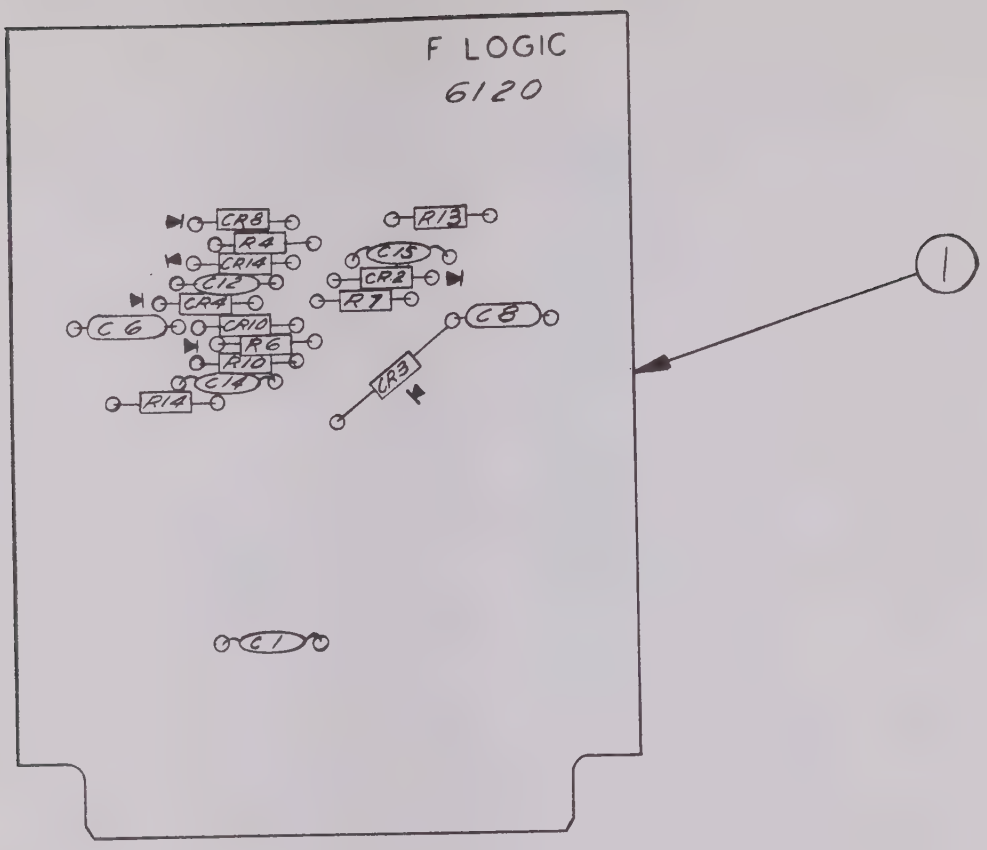
MODIFICATION A4

Two additional digits of visual, storage, and readout BCD capability is provided with this modification.

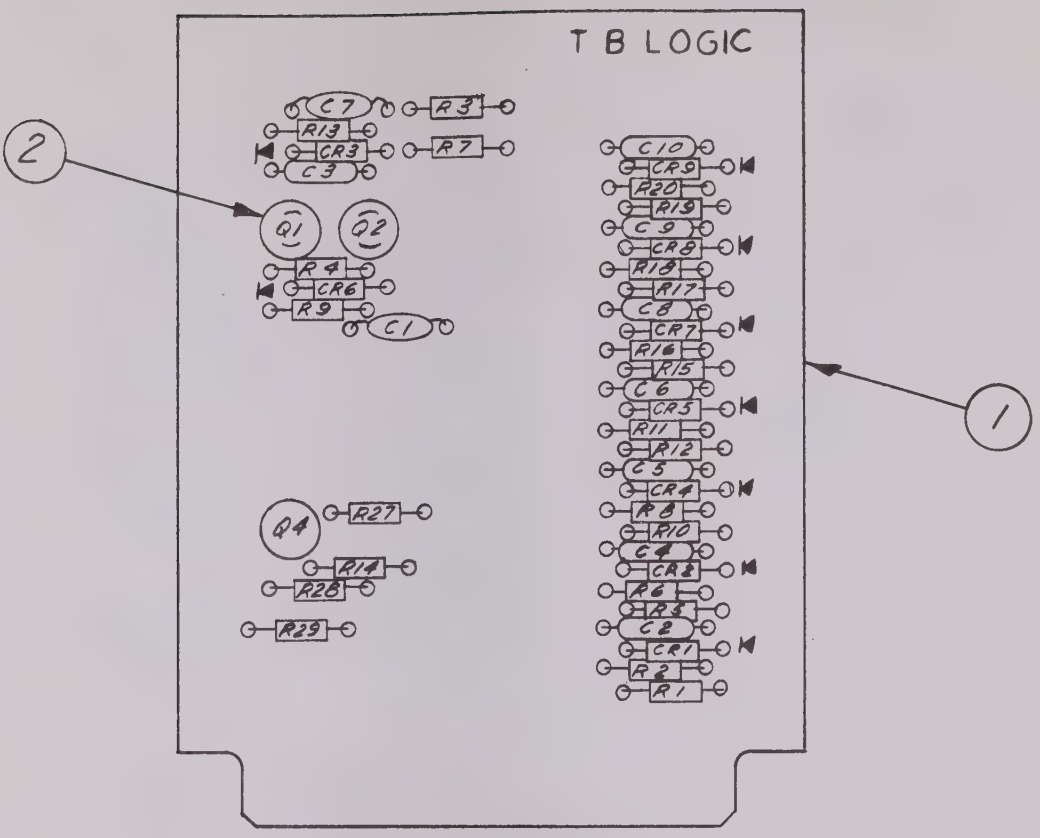


1) 25 Mc Amplifier P. C. Board (887-414707)
2) Pad, Converter Transistor
3) Heat Sink

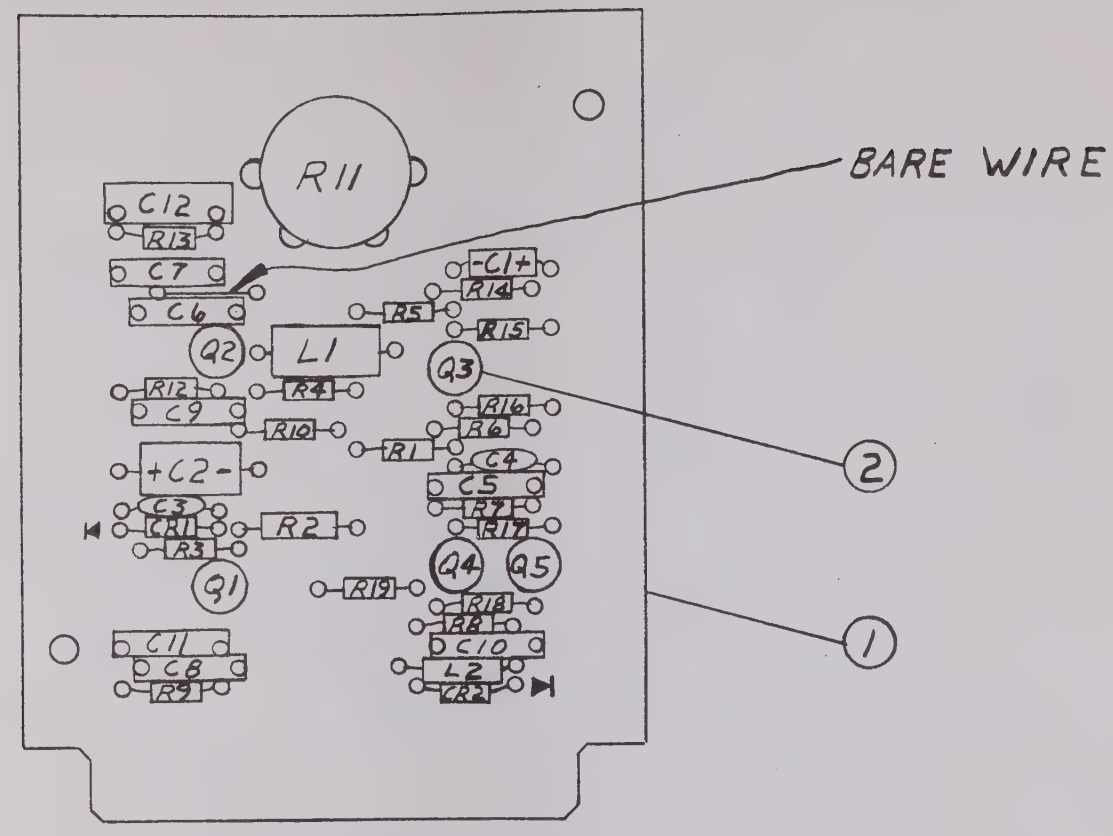
Beckman



1) F Logic P.C. Board (887-422376)

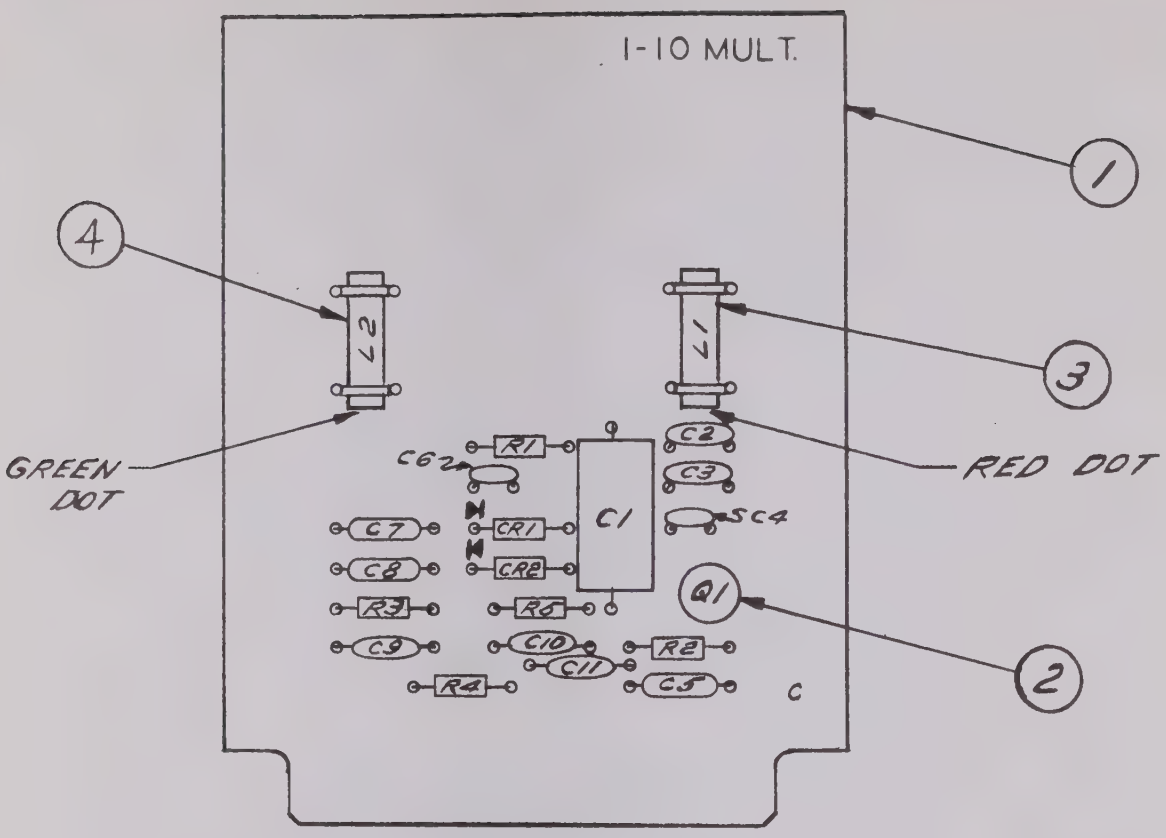


1) Time Base Logic P.C. Board (887-422422)



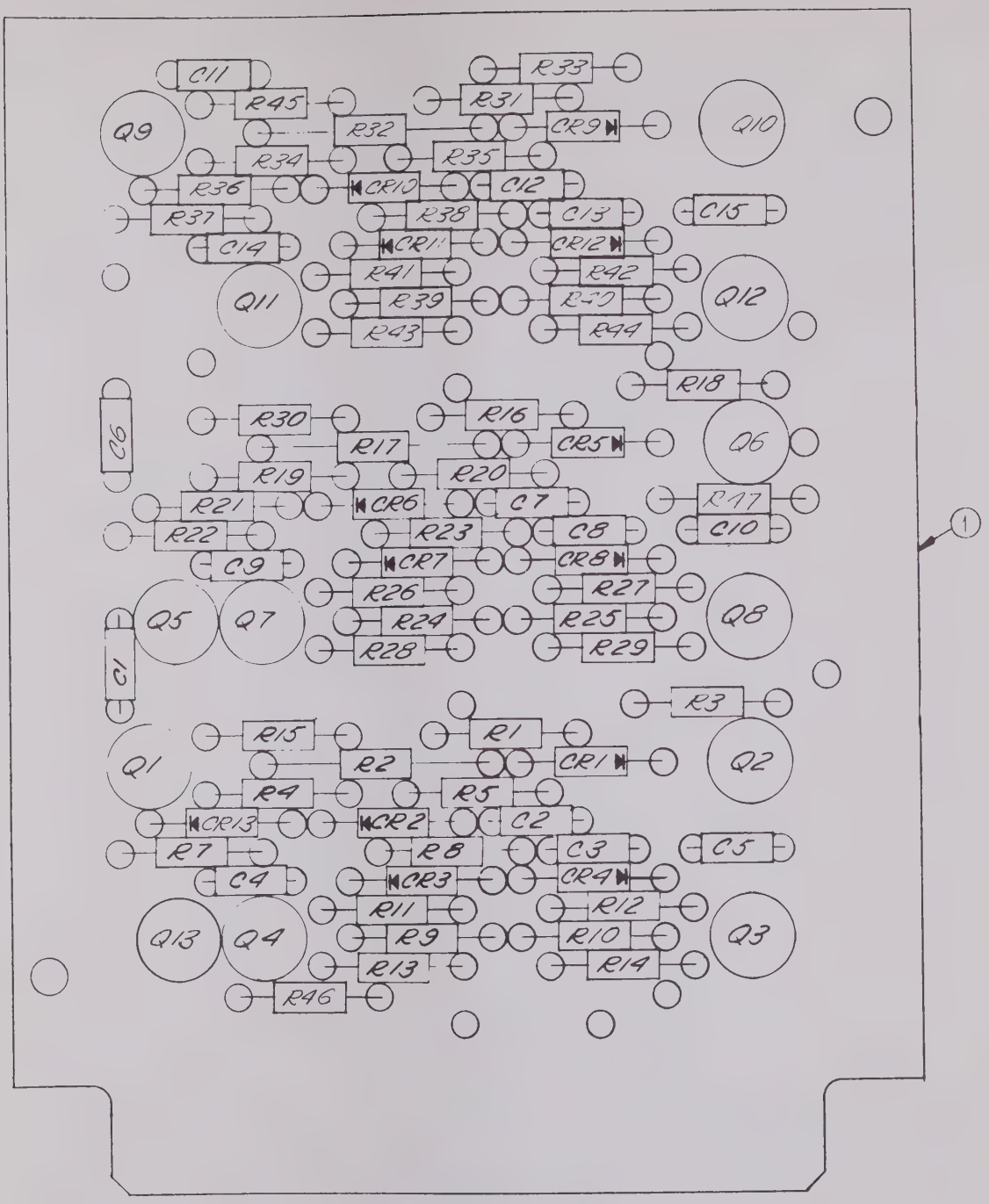
1) Oscillator P.C. Board (887-411676)
2) Pad, Converter Transistor

Beckman



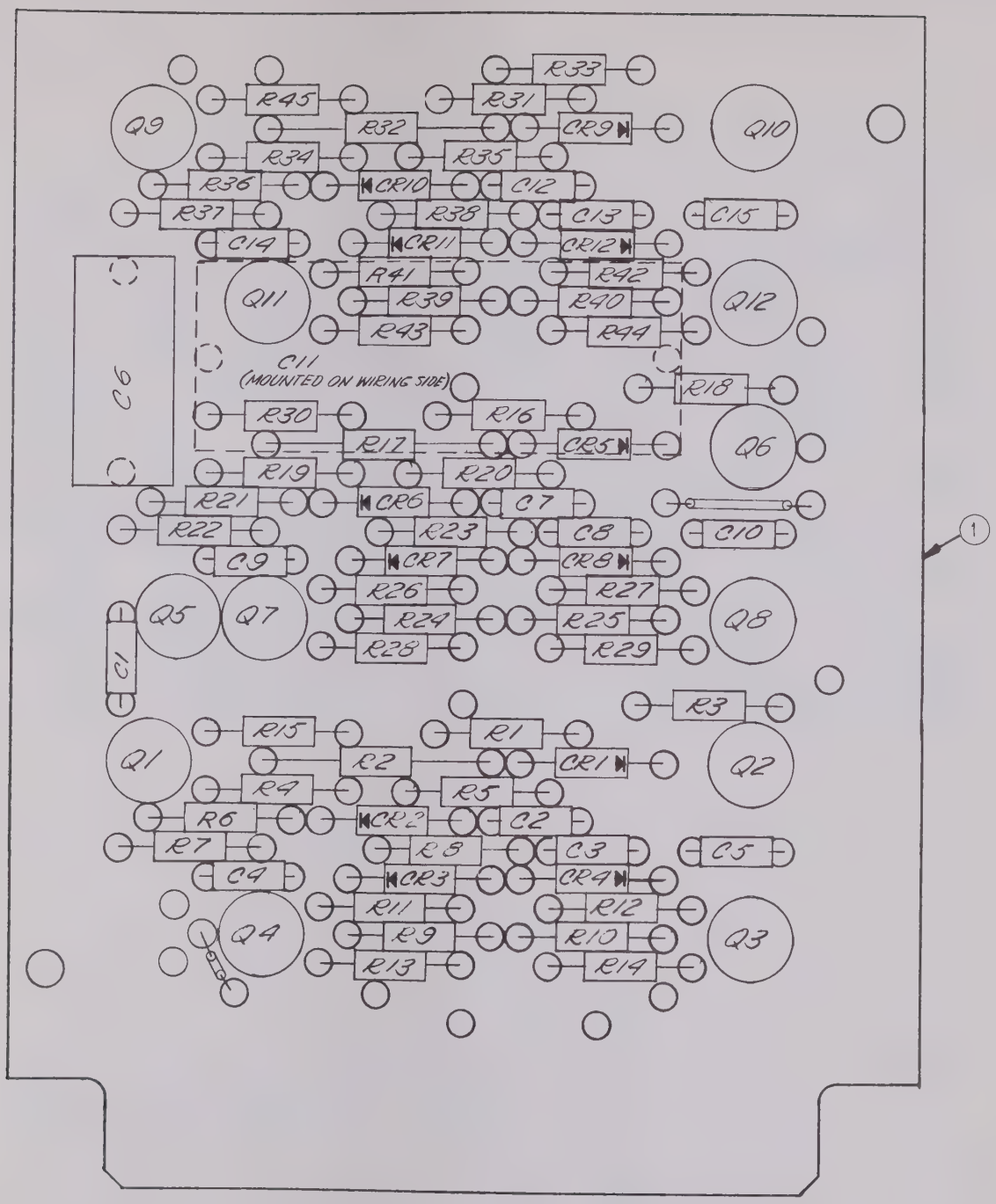
1) 1-10 Mc Multiplier P. C. Board (887-412605)
2) Pad, Converter Transistor
3) Variable Inductor, L1
4) Variable Inductor, L2

Beckman



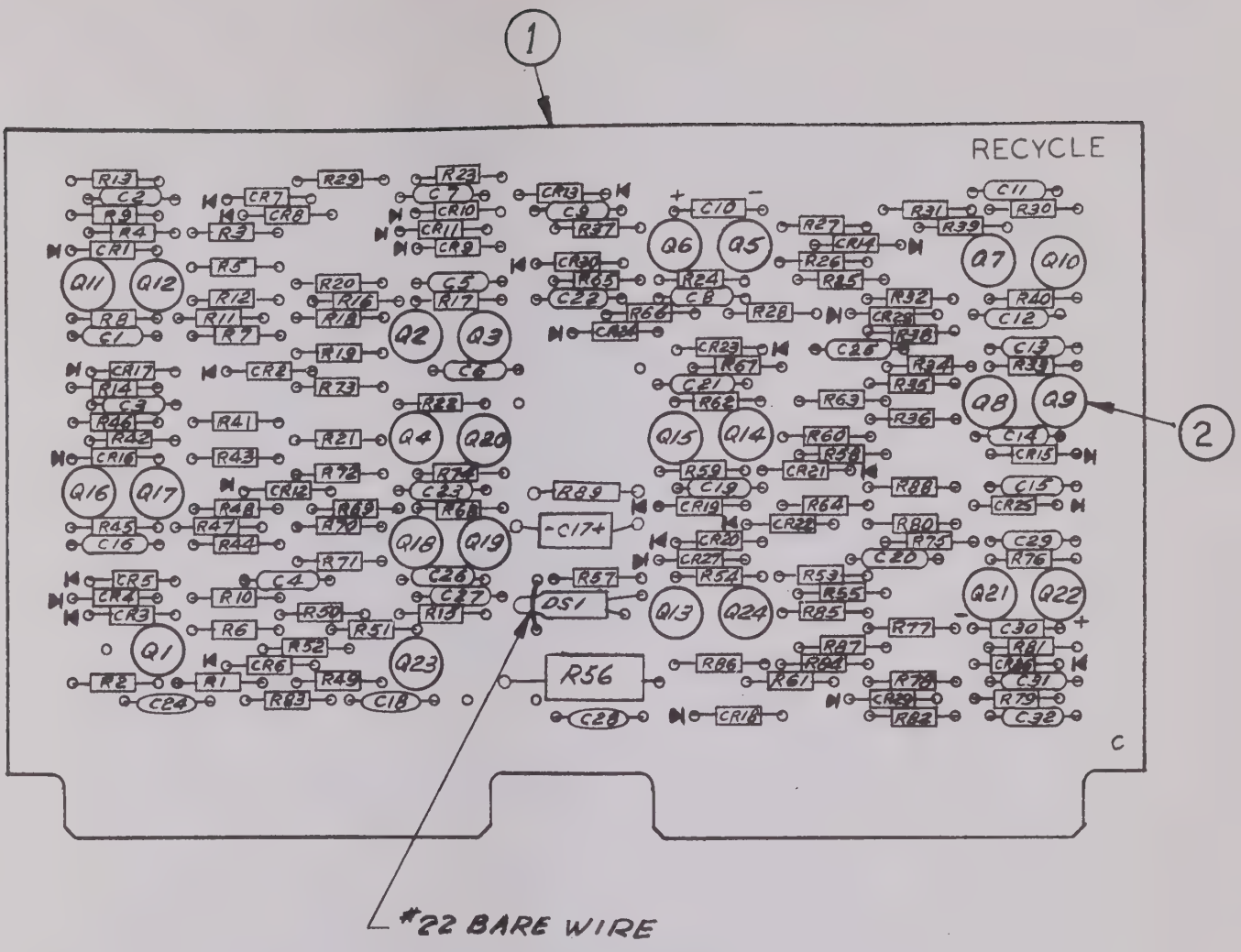
1) 1st Divider P. C. Board (887-422002)

Beckman

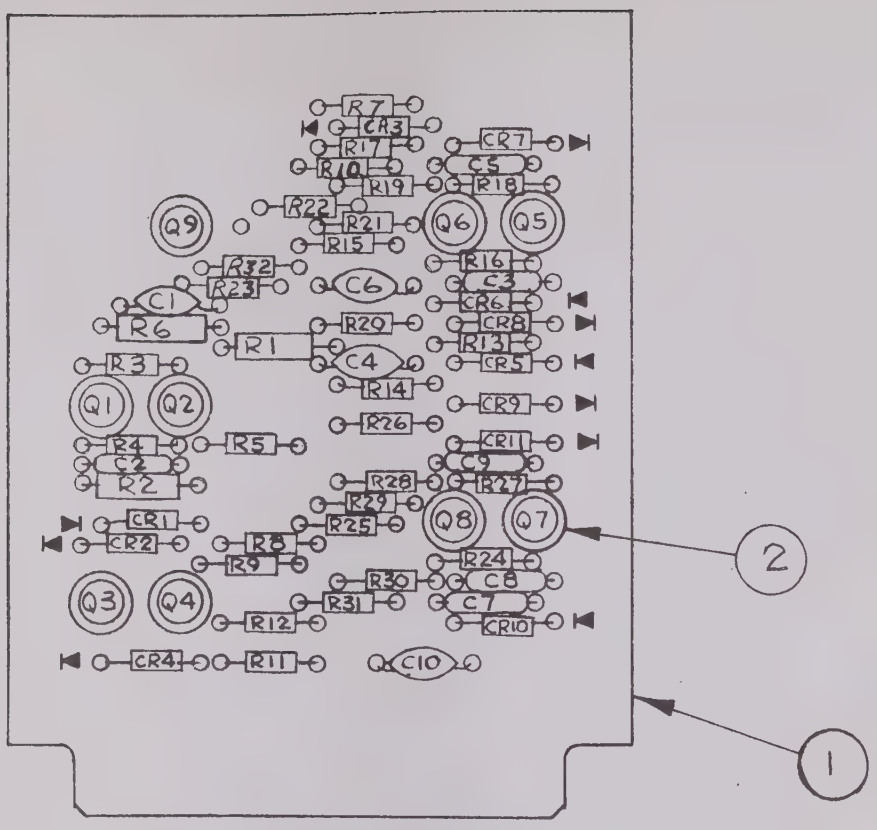


1) 2nd Divider P.C. Board (887-422003)

Beckman®

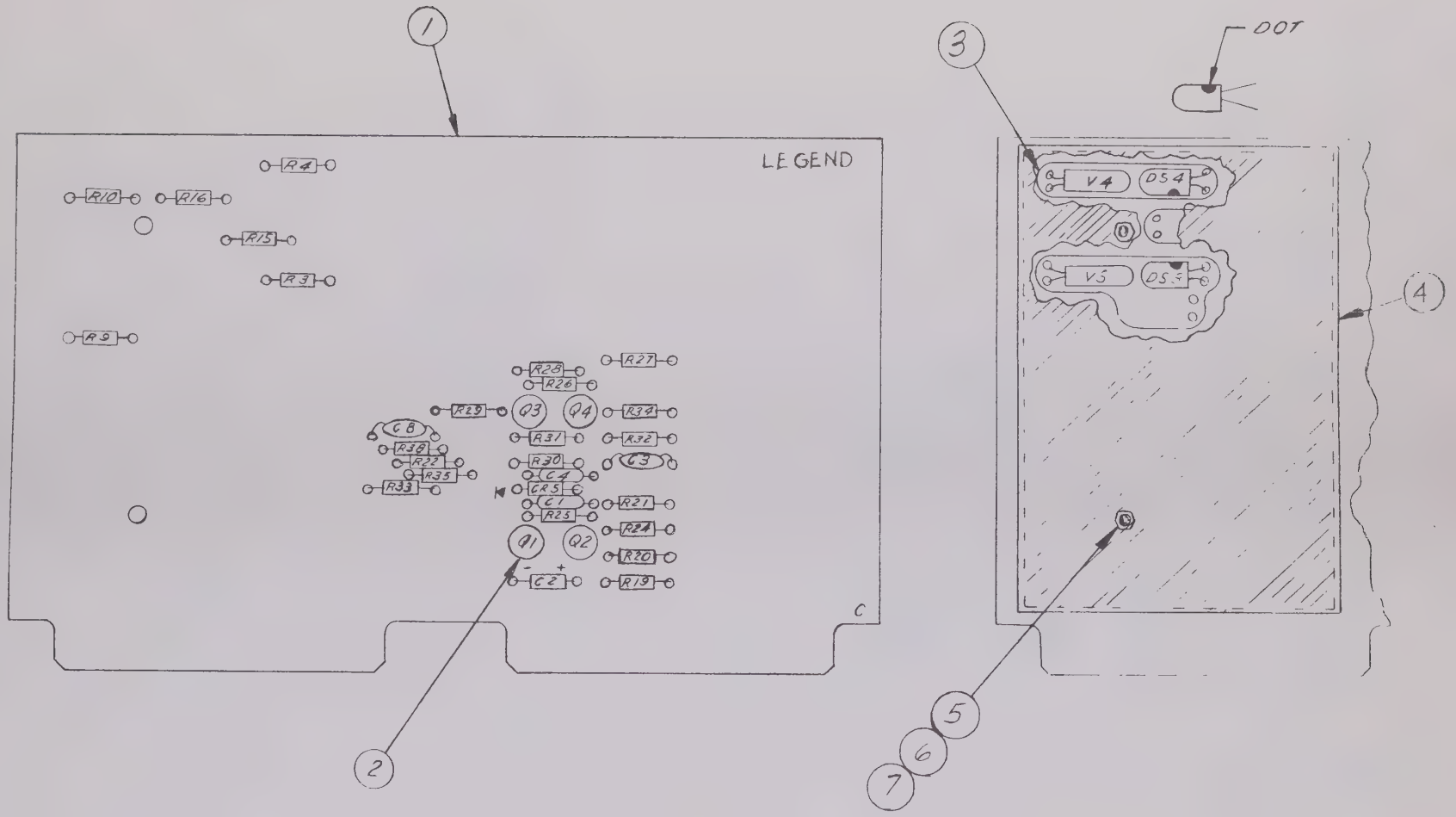


1) Recycle P.C. Board (887-411673)
2) Pad, Converter Transistor



1) Control P.C. Board (887-410903)
2) Pad, Converter Transistor

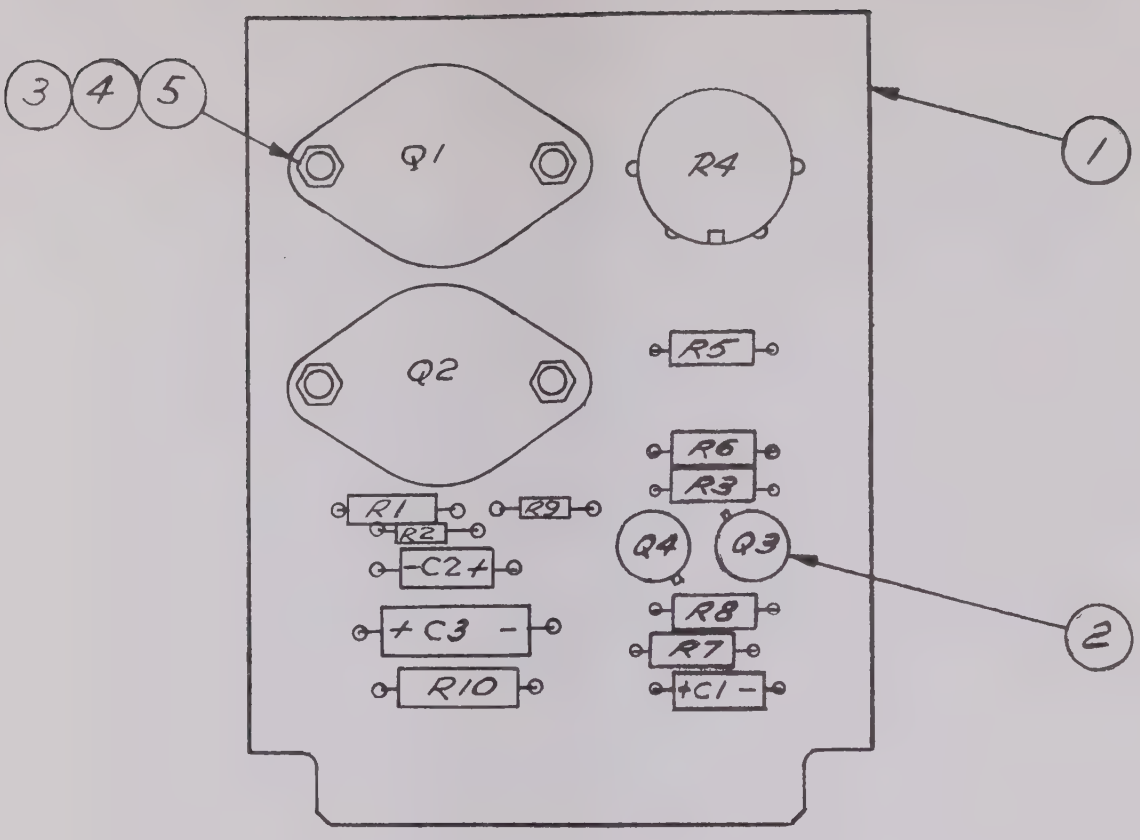
Beckman



1) Legend P.C. Board (887-422431)
2) Pad, Converter Transistor
3) Lamp Block, Base
4) Lamp Block Cover
5) #4 40 x 3/8" L. FHMS (100°)
6) Washer, Shake, Outside Star
7) #4 Hex Nut (SM PATT)

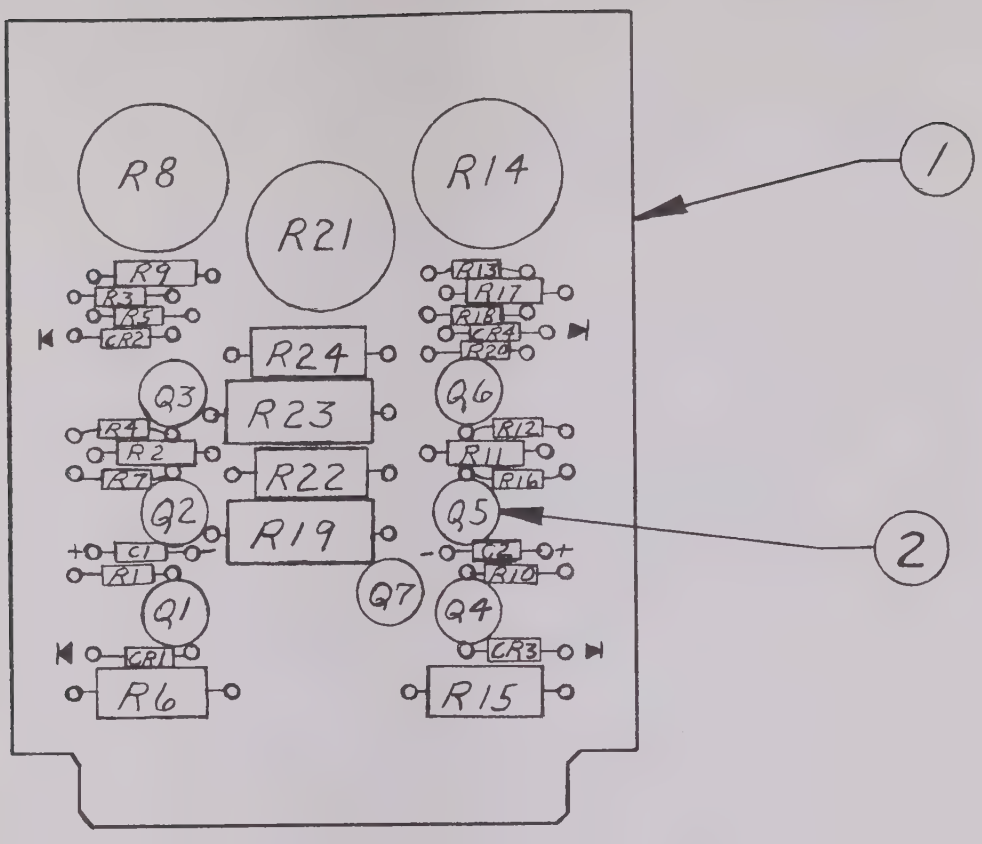
Model 6120
Legend P.C. Bd.
E-422431-Rev. A
February 1965

Beckman



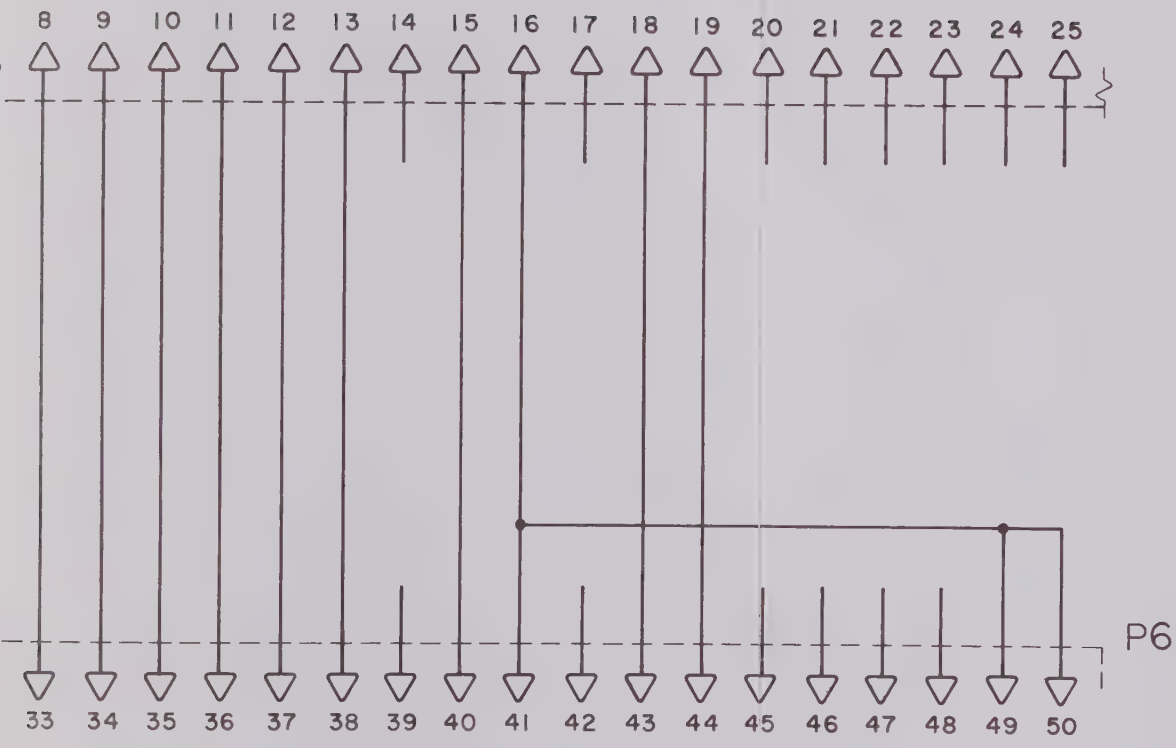
1) EL Supply P.C. Board (887-412795)
2) Pad, Converter Transistor
3) 6-32 x 3/8 FHMS (100^{o})
4) #6, Int. Tooth Lock Washer
5) #6, Nut, Sm. Patt.

Beckman



1) Regulator P.C. Board (887-412442)
2) Pad, Converter Transistor

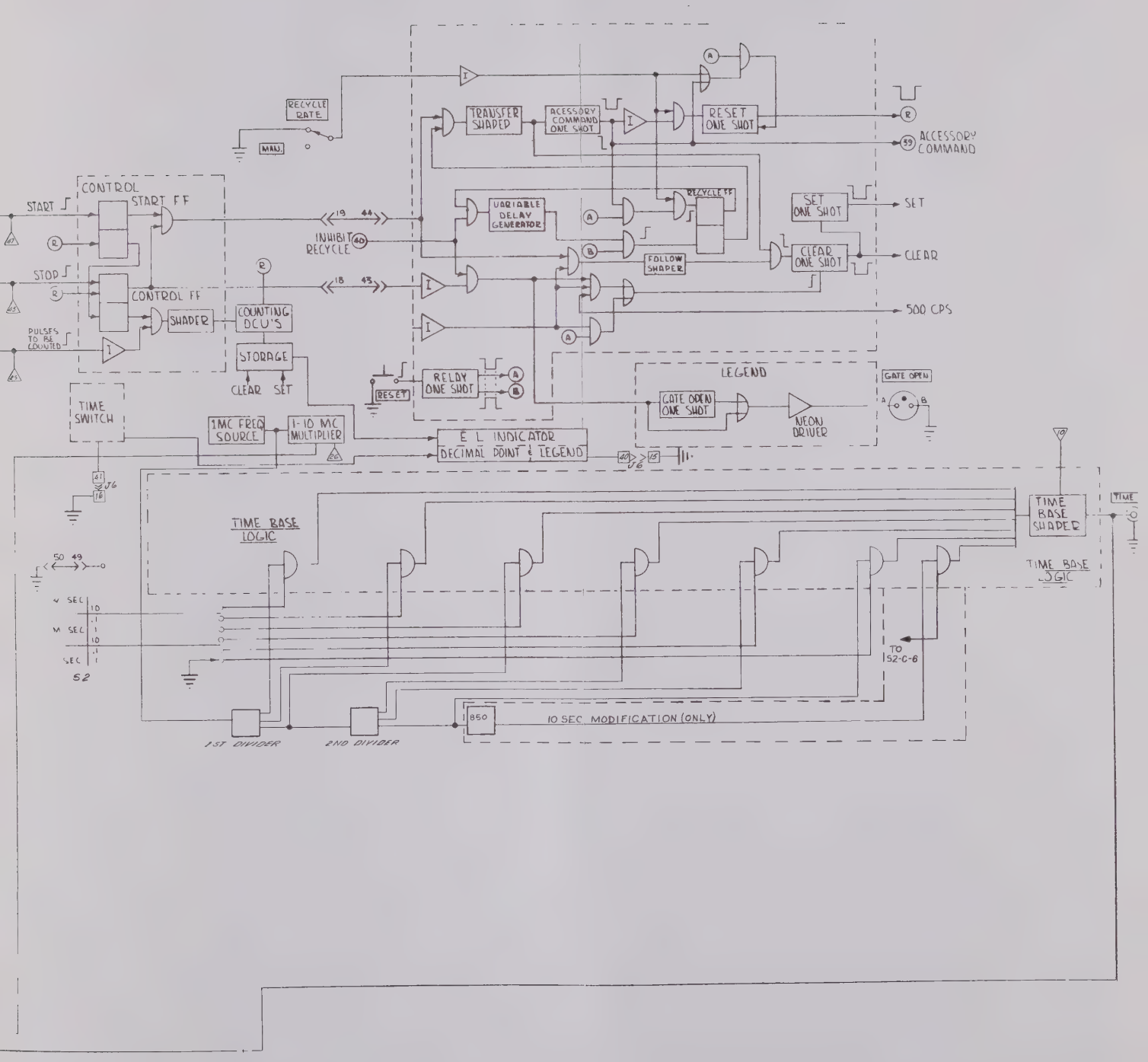
MODEL 696 PLUG-IN
SCHEMATIC DIAGRAM



6100 Series
64B-6100-001-Rev
January 1965

Beckman

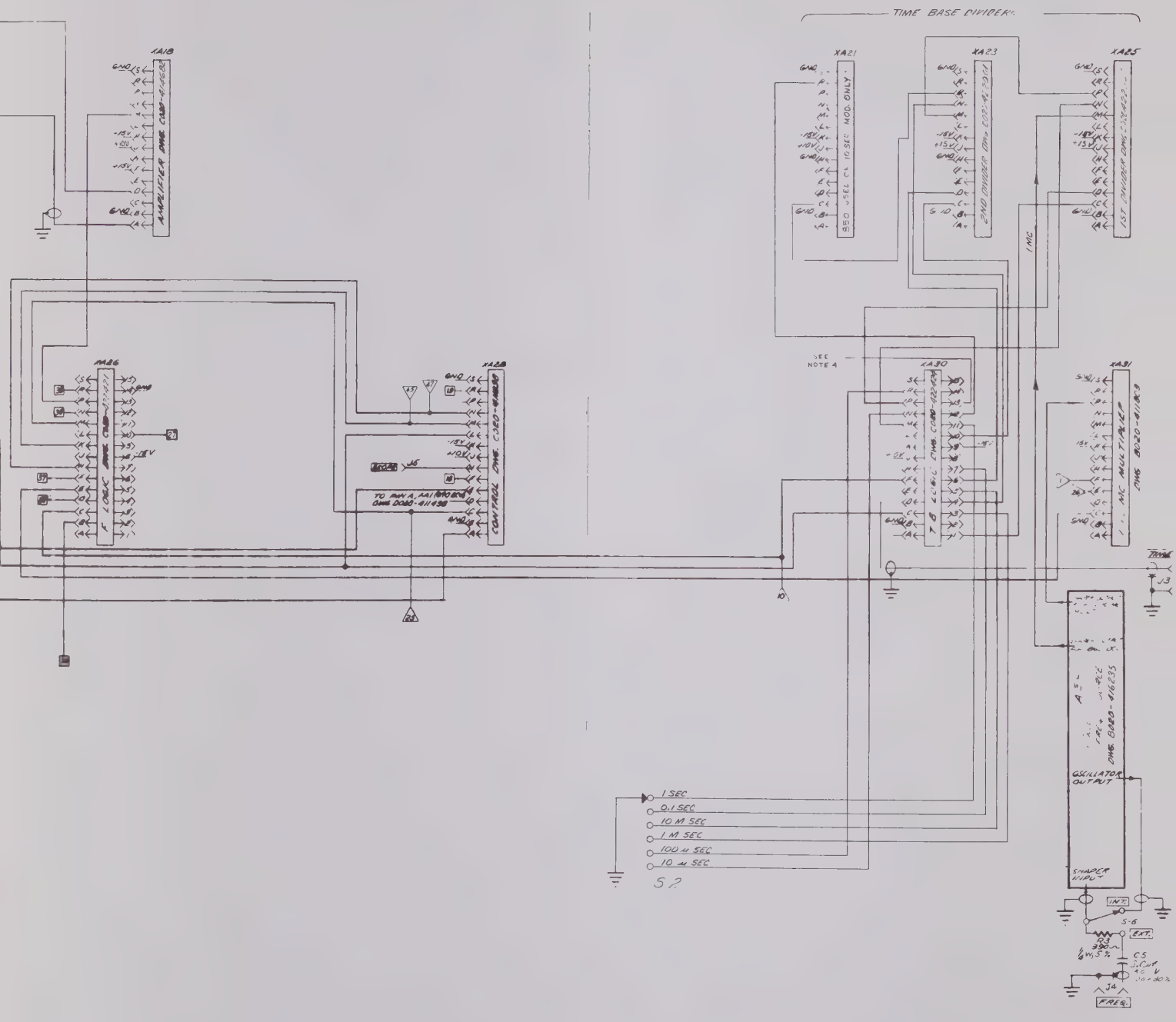
MODEL 6120
BLOCK DIAGRAM



Model 6120
D 422808-Rev. A
February 1965

Beckman

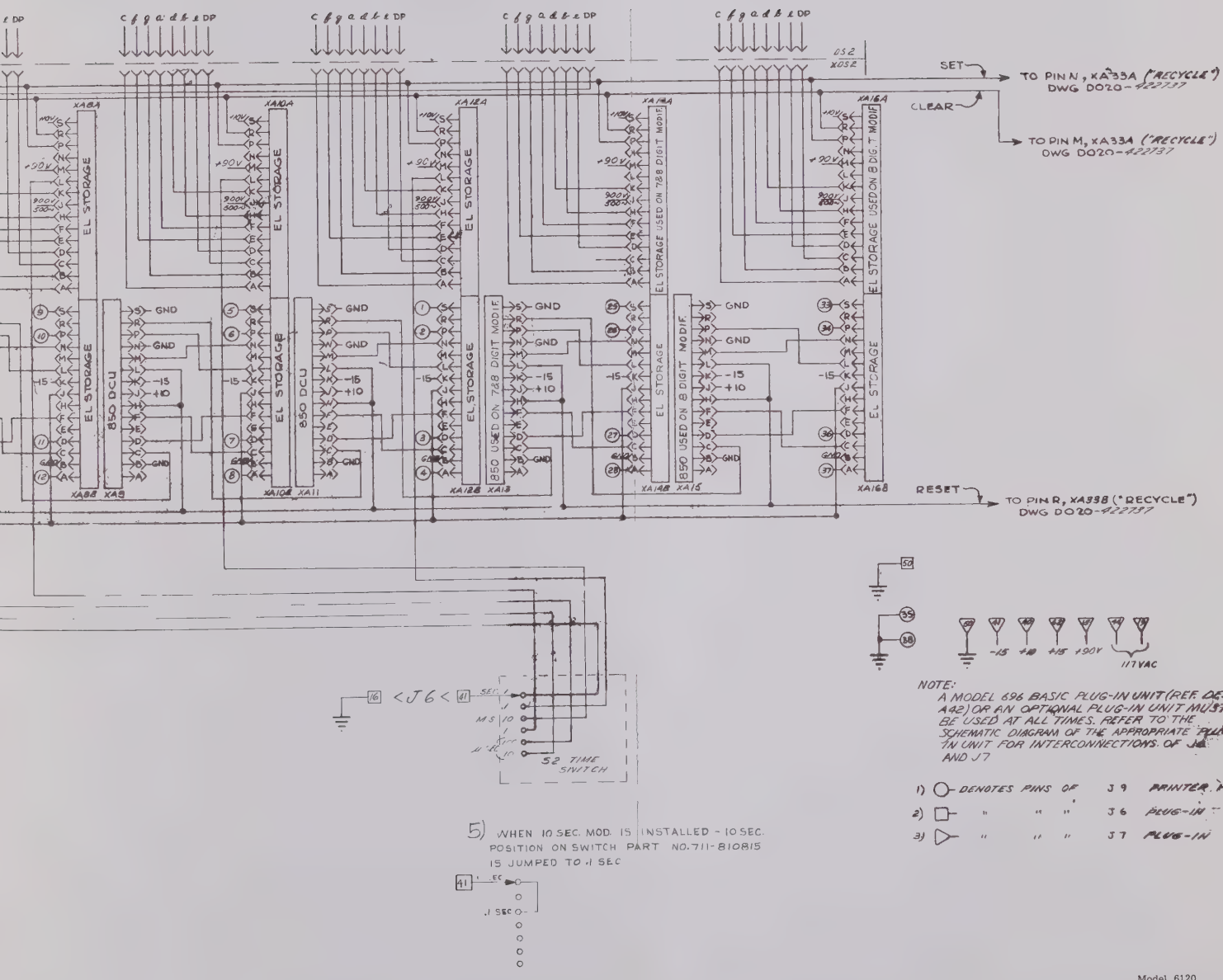
MODEL 6120
UNIT LOGIC
SCHEMATIC DIAGRAM



Model 6120
D422737-Rev. A
February 1965

Beckman®

MODEL 6120
COUNT
SCHEMATIC DIAGRAM



NOTE:
A MODEL 696 BASIC PLUG-IN UNIT (REF. DES. A42) OR AN OPTIONAL PLUG-IN UNIT MUST BE USED AT ALL TIMES. REFER TO THE SCHEMATIC DIAGRAM OF THE APPROPRIATE PLUG-IN UNIT FOR INTERCONNECTIONS OF J6 AND J7

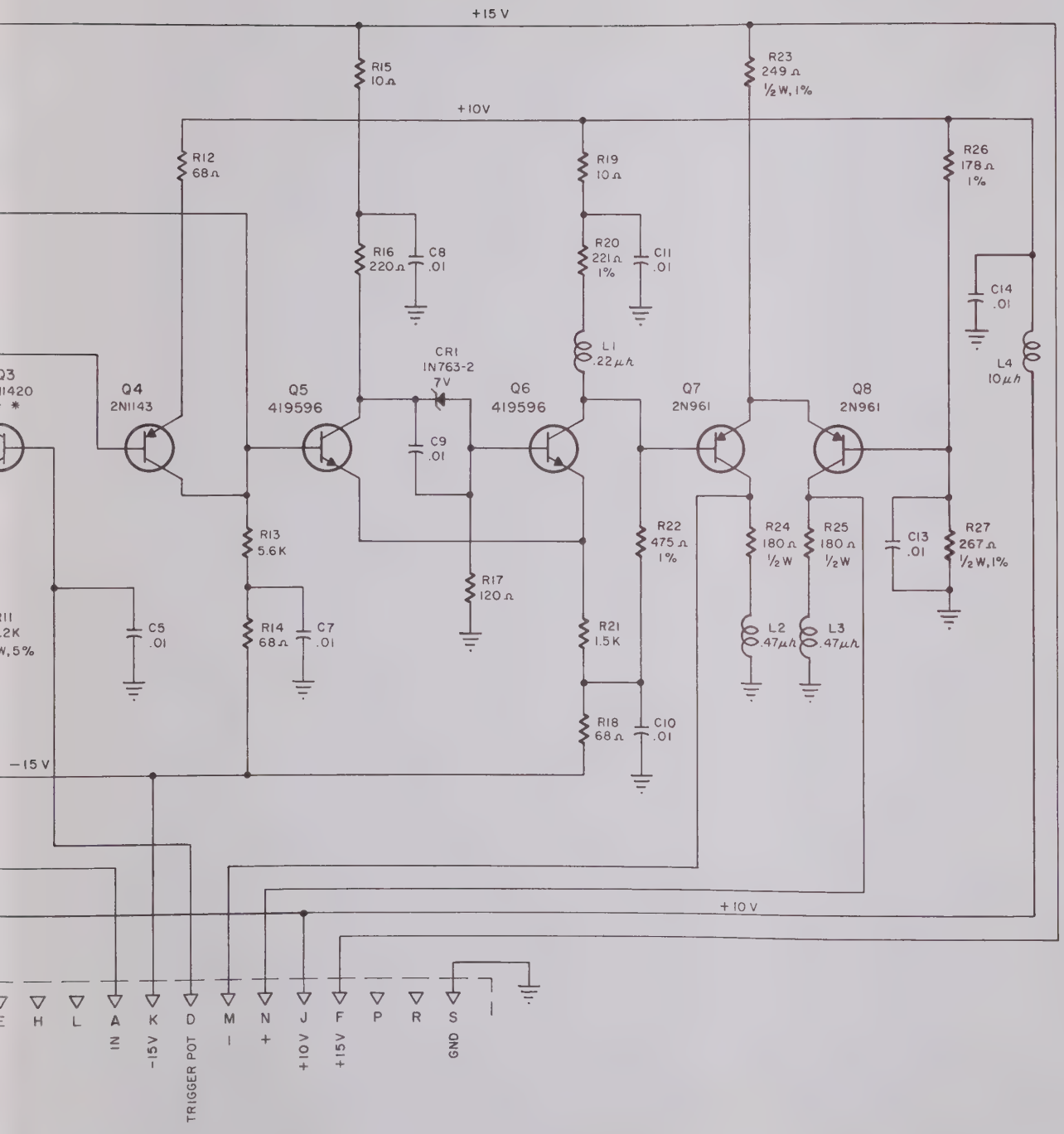
1) ○ DENOTES PINS OF J9 PRINTER MOD.
2) □ " " " J6 PLUG-IN
3) ▷ " " " J7 PLUG-IN

5) WHEN 10 SEC. MOD. IS INSTALLED - 10 SEC. POSITION ON SWITCH PART NO. 711-810815 IS JUMPED TO .1 SEC

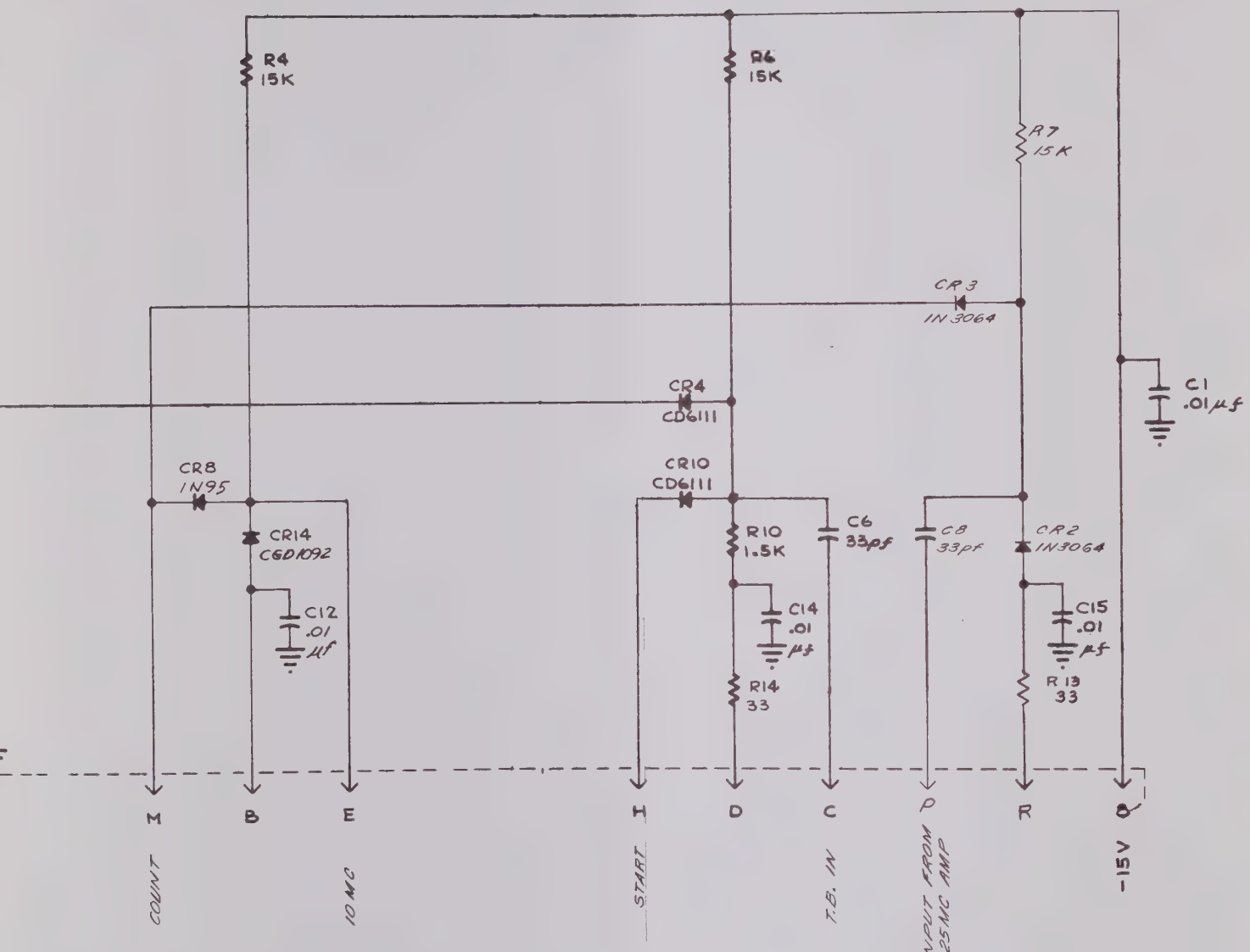
Model 6120
D422785-Rev. A
February 1965

Beckman

25 MC INPUT AMPLIFIER
SCHEMATIC DIAGRAM

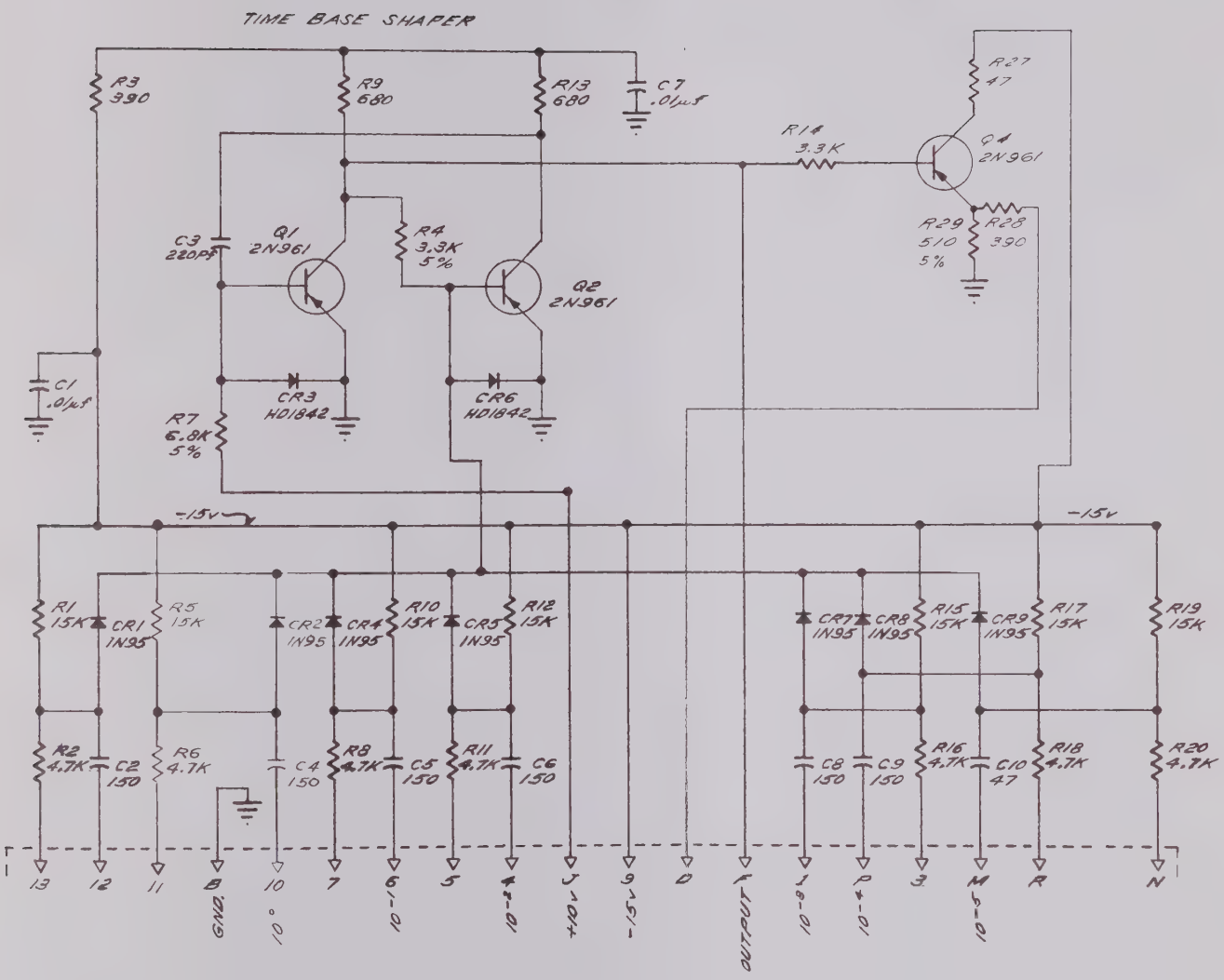


MODEL 6120
F LOGIC
SCHEMATIC DIAGRAM



Beckman

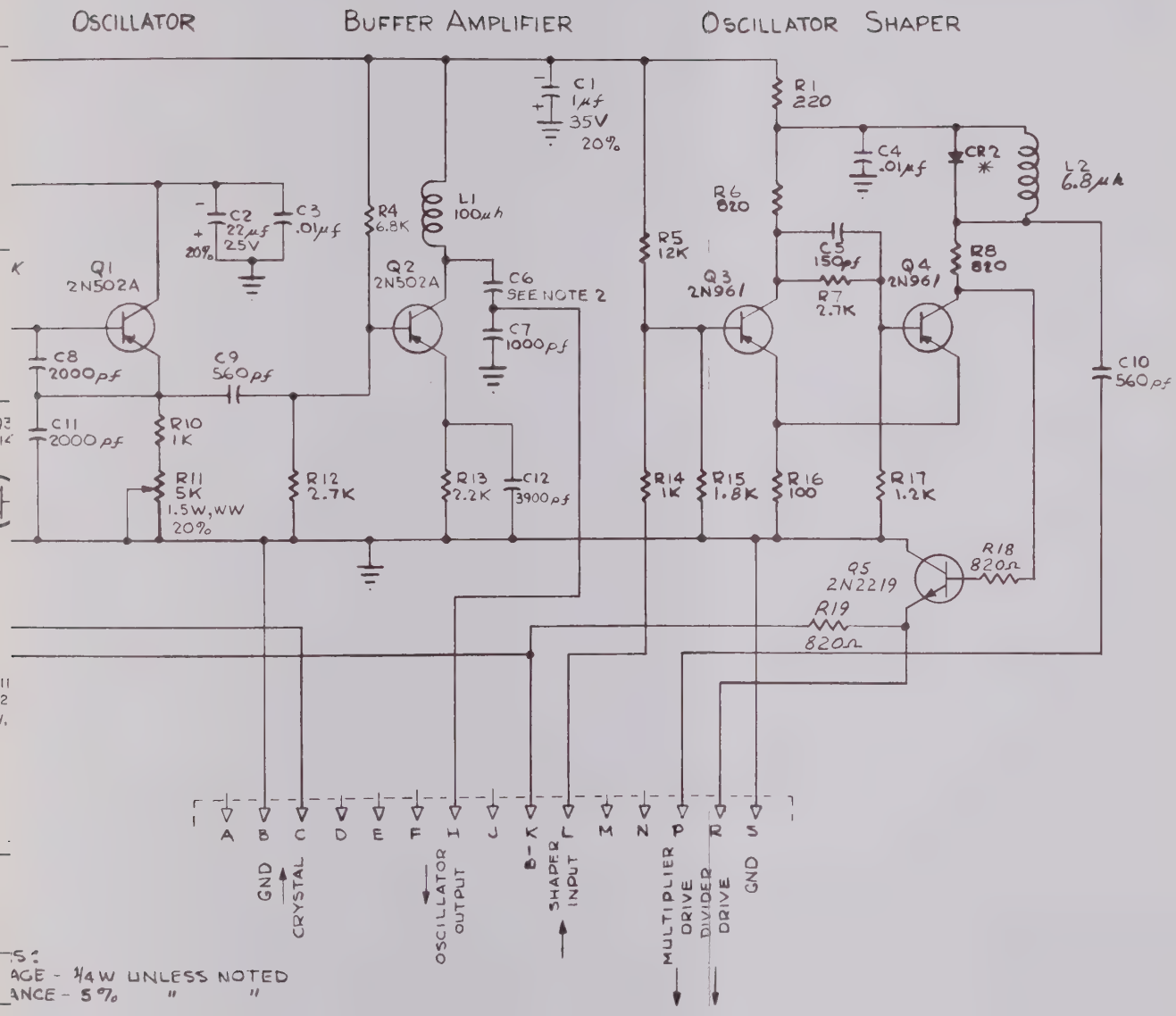
TIME BASE LOGIC
SCHEMATIC DIAGRAM



Models 6120, 6121
C 422424-Rev. A
February 1965

Beckman

1MC OSCILLATOR & SHAPER
SCHEMATIC DIAGRAM



S:
AGE - 1/4W UNLESS NOTED
ANCE - 5% " "

NALLY 300pf. IF OSCILLATOR OUTPUT
THAN 3V PP, CHANGE TO 330pf

ORS:
RANCE — 5% UNLESS NOTED
TAGE — 300V " "

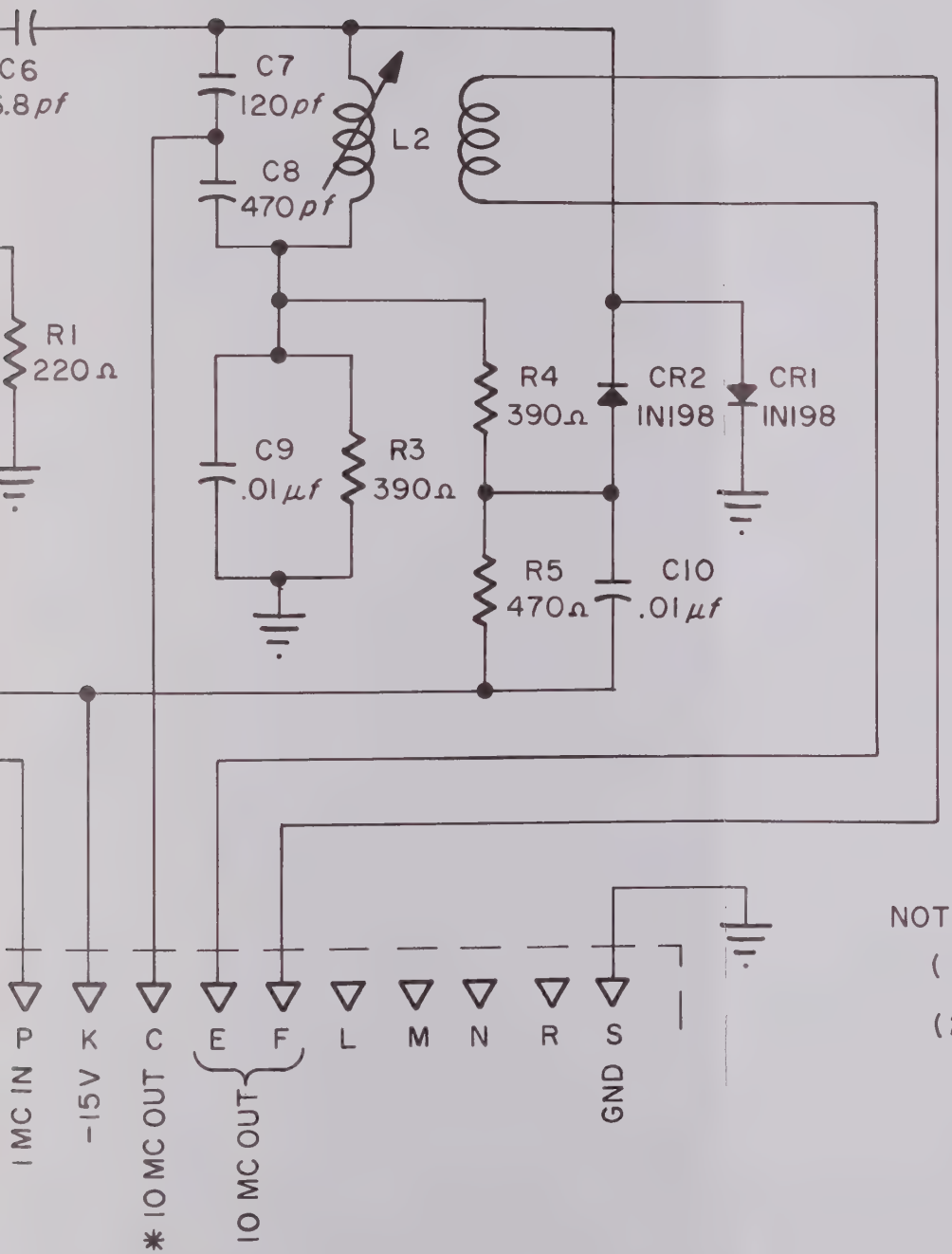
SC ARE -20+80%, 500V

BDB #755-402107

Models: 6120, 6121, 6144
C411996-Rev. C
February 1965

Beckman®

1 - 10 MC MULTIPLIER SCHEMATIC DIAGRAM



NOTES:

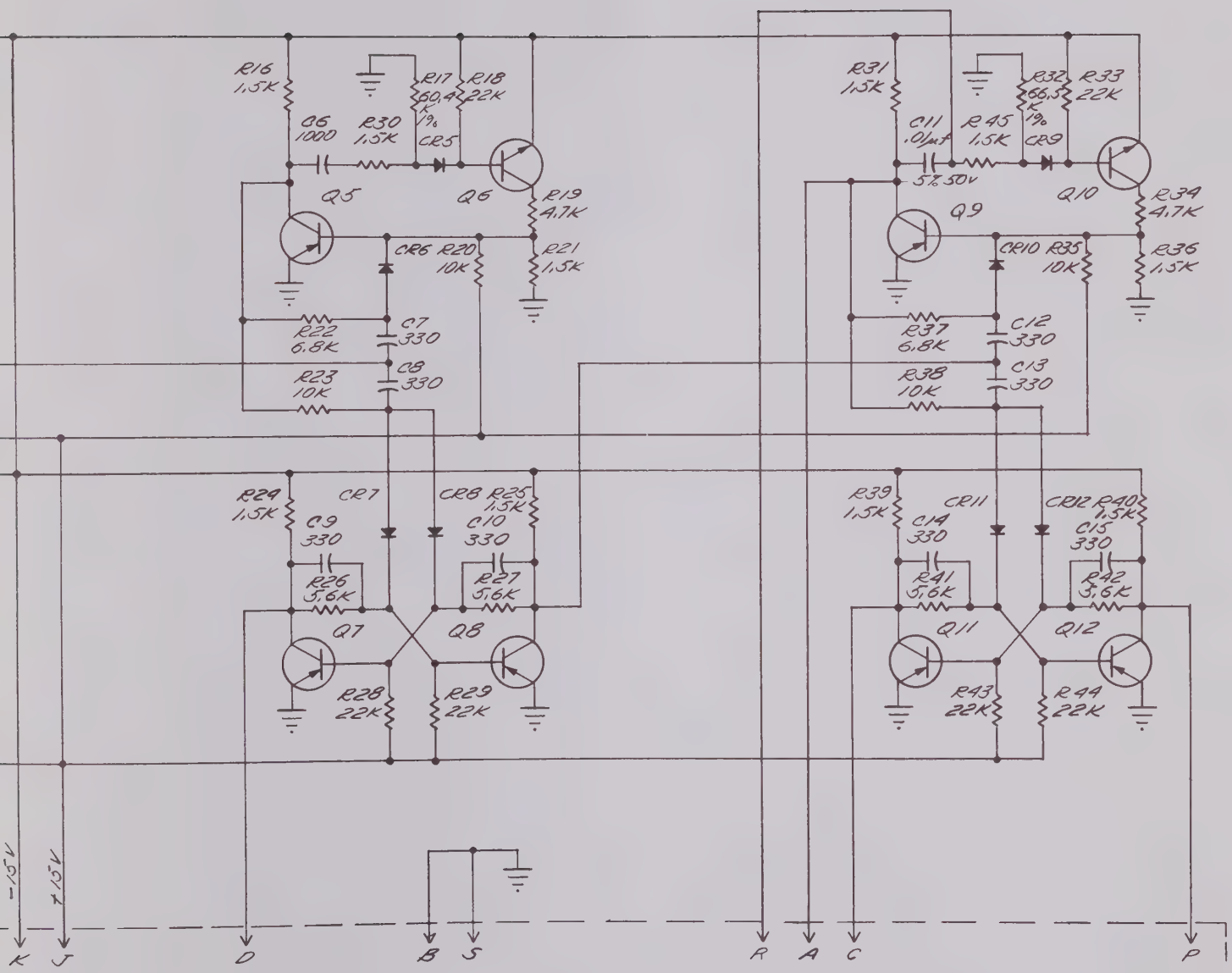
(1) RESISTORS ARE 1/4W, 5%

(2) * TO DRIVE COUNT GATE CIRCUITRY.

Models: 6120, 6121
6126, 6127, 6146, 6147
64B-6100-004-Rev. B
September 1964

Beckman

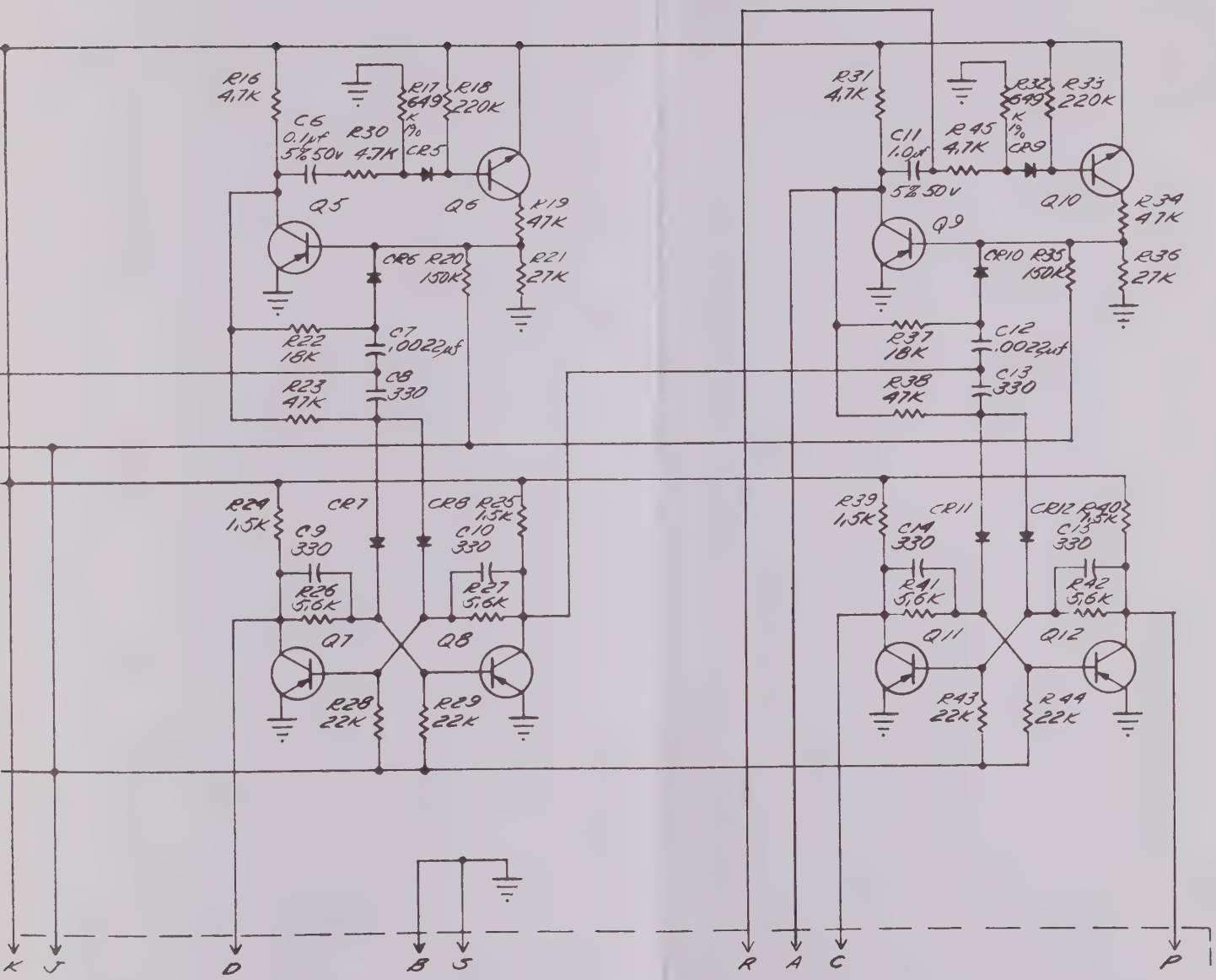
FIRST DIVIDER
SCHEMATIC DIAGRAM



OTED.
"
"

Beckman

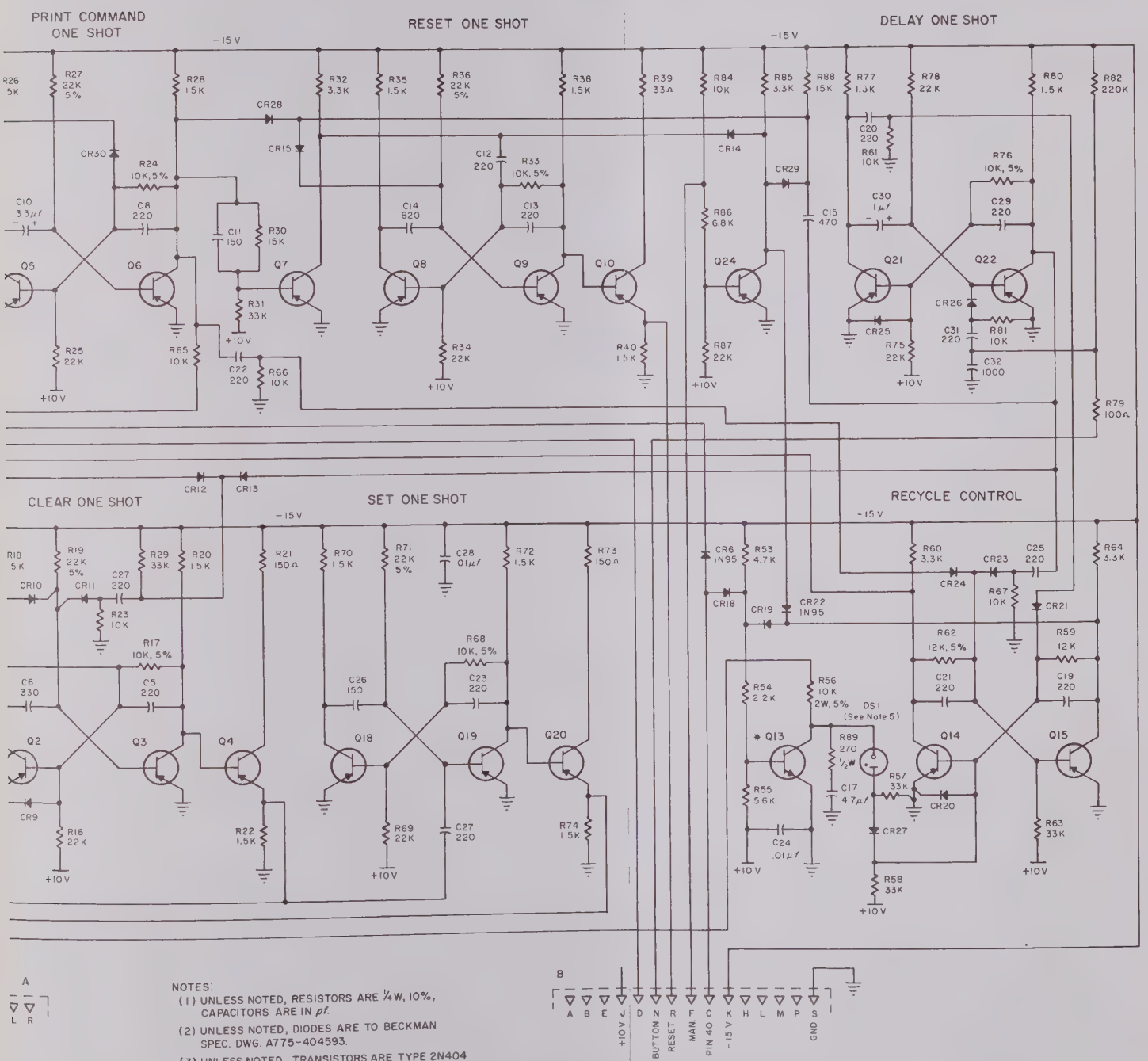
SECOND DIVIDER
SCHEMATIC DIAGRAM



TED.
N
11

Beckman®

RECYCLE
SCHEMATIC DIAGRAM



NOTES:

(1) UNLESS NOTED, RESISTORS ARE ¼W, 10%, CAPACITORS ARE IN *pf*.

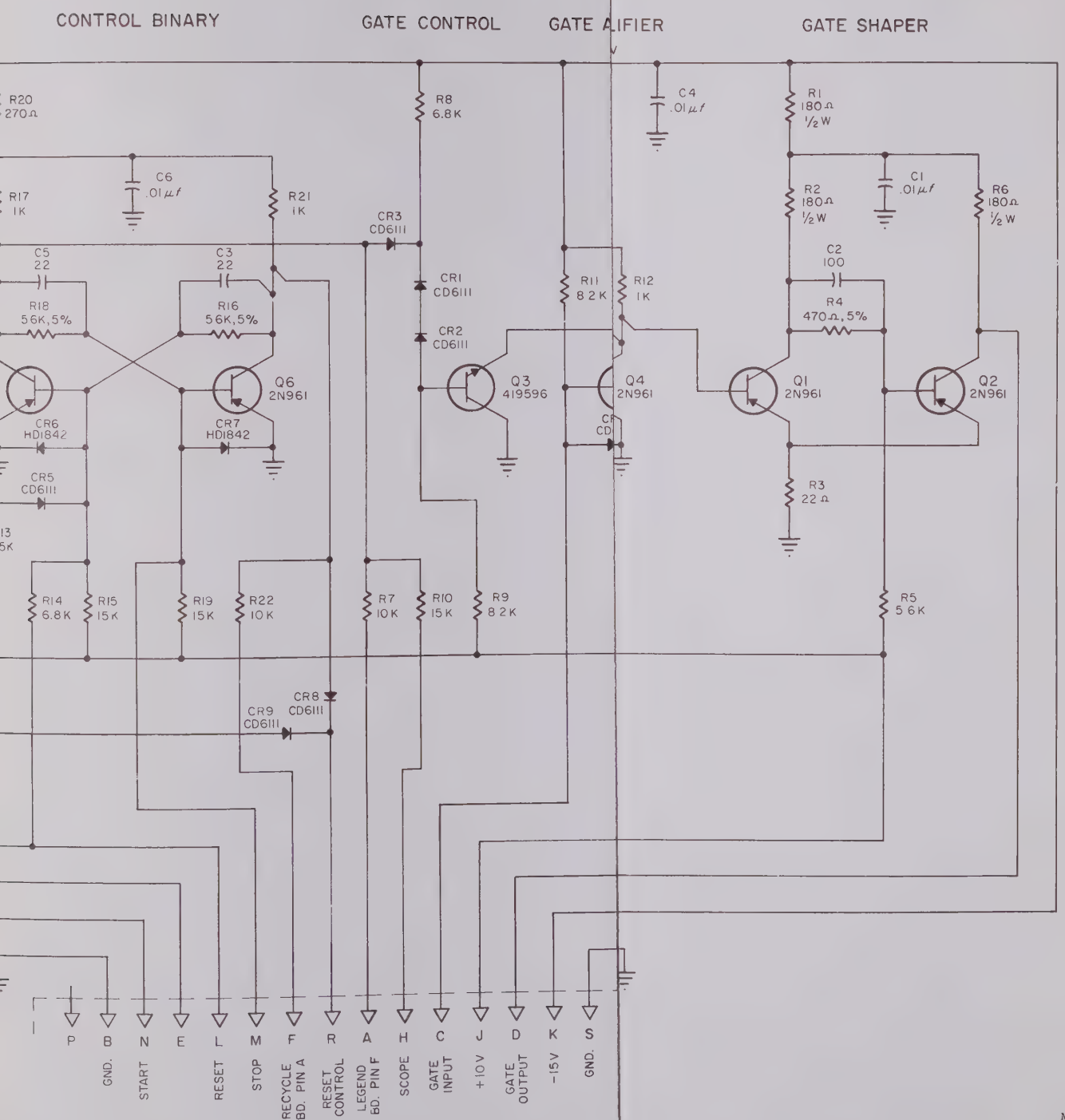
(2) UNLESS NOTED, DIODES ARE TO BECKMAN SPEC. DWG. A775-404593.

(3) UNLESS NOTED, TRANSISTORS ARE TYPE 2N404

(4) * TRANSISTOR IS TO BECKMAN SPEC. DWG. A775-410066

(5) DS1, TO BECKMAN SPEC. DWG. A825-414955

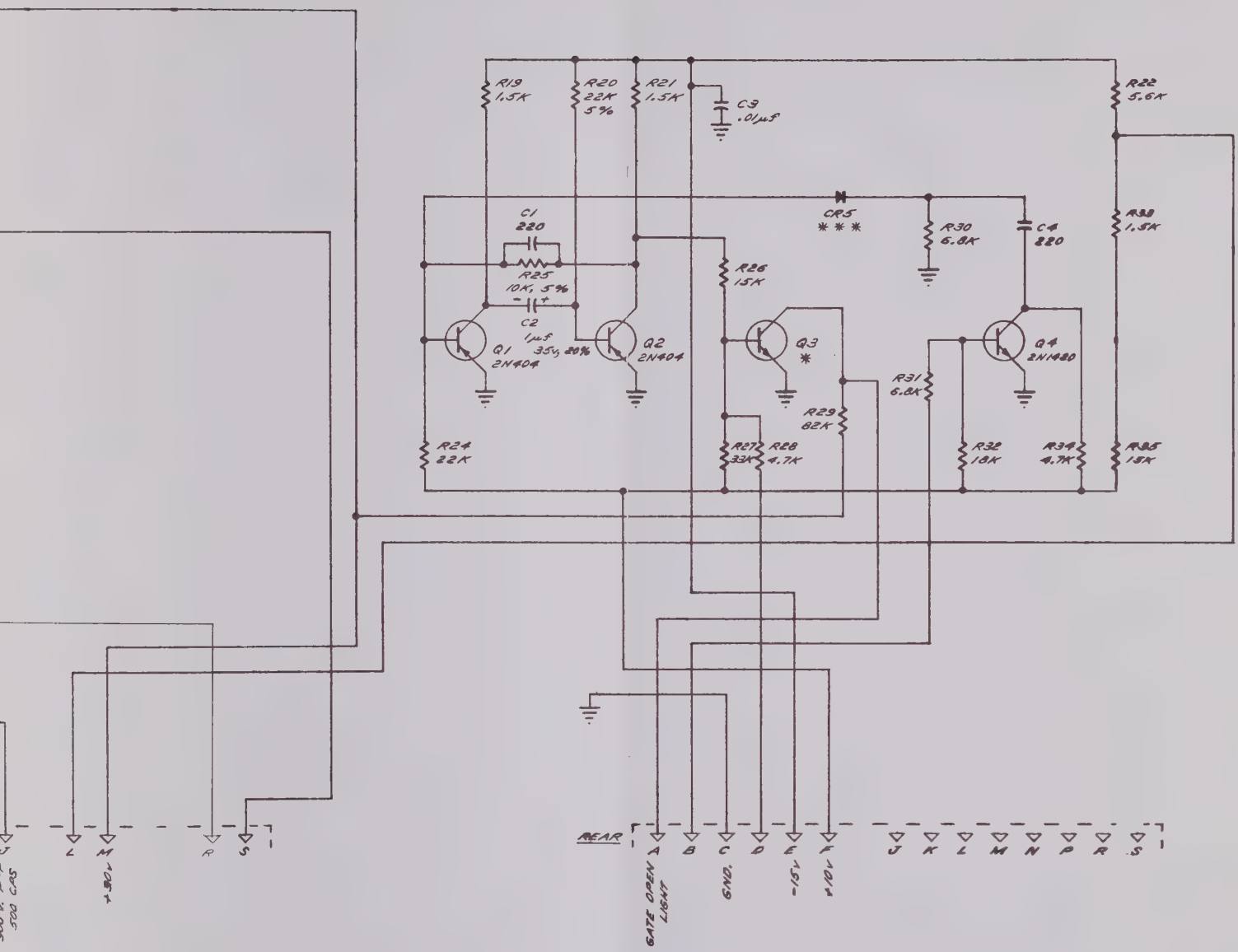
CONTROL
SCHEMATIC DIAGRAM



Models: 6120, 6126, 6144 6146
84C-6100-014-Rev. F
January 1965

Beckman

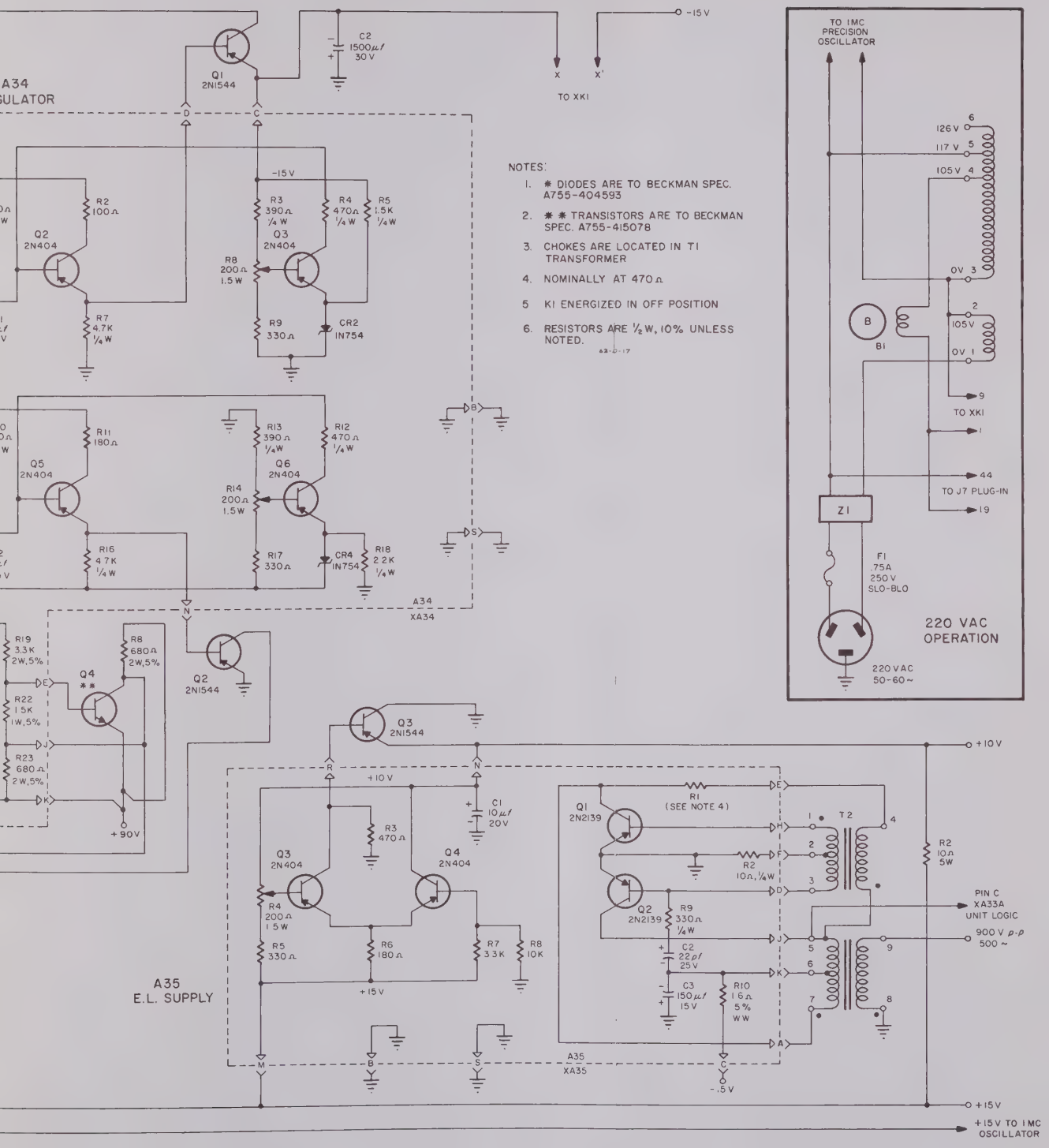
LEGEND
SCHEMATIC DIAGRAM



Models 6120, 6121
D 422433-Rev. A
February 1965

Beckman

POWER SUPPLY SCHEMATIC DIAGRAM

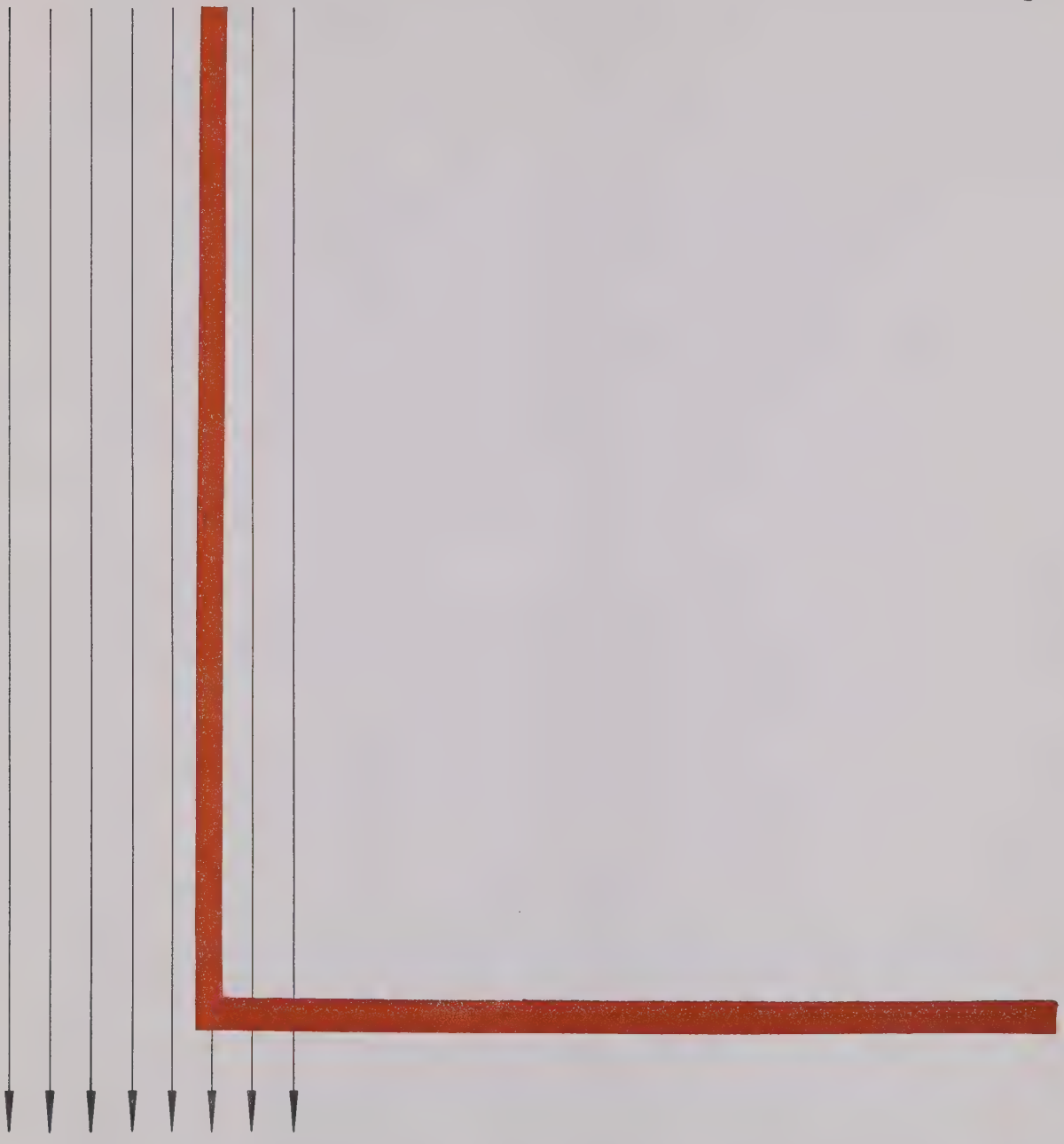


6100 Series
64D-6100-023-Rev. I
September 1964

Beckman®

INSTRUCTION MANUAL

MODEL 870
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.
BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

December 1962

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

CONTENTS

		Page
SEC. 1	INTRODUCTION	
	1.1 General Description	1-1
	1.2 Technical Characteristics	1-1
SEC. 2	OPERATION	
	2.1 Mounting the Unit	2-1
	2.2 Supplying Power	2-1
	2.3 Supplying Input Signals	2-1
	2.4 State of the Binaries	2-1
	2.5 Using Output Signals	2-1
	2.6 Resetting Unit to Zero	2-2
SEC. 3	CIRCUITS	
	3.1 The Binaries	3-1
	3.2 The Scale-of-Ten Circuit	3-2
SEC. 4	PARTS LIST	
DIAGRAMS		
	Model 870 DCU Component Layout	3-5
	Model 870 DCU Schematic (D411637)	

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 870 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit provides a count of input pulses from zero to nine, each count being represented by output signals in 1-2-4-8 binary coded decimal form. With an Electroluminescent Storage Unit, this binary-coded decimal output can be converted into a decimal digit display of the registered count.

At every tenth input pulse the DCU generates an output signal that can be used to drive a Model 860 or 870 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 TECHNICAL CHARACTERISTICS

Input Requirements

Positive pulse or voltage step, 5 volts minimum to 7 volts maximum amplitude from a source impedance of 180 ohms or less; 6 nanosecond rise time. Pulse duration of 15 nanoseconds, minimum.

Counting Rate

0 - 25 Mc.

No Count Indication

Use with Electroluminescent Storage Unit for visual indication of stored count.

Out put Characteristics

1) 1-2-4-8 permuted binary code.

2) Emitter-follower output with 1K Ω emitter resistance to +10 volt.

3) Carry pulse designed to drive a following Model 860 DCU or another Model 870 DCU.

4) One output is available from each binary: -0. 2 volts for binary 1, -6. 0 volts for binary 0. Each binary will supply 2 ma to the Electroluminescent Unit.

Transfer Time

25 nanoseconds between application of 10th input pulse and start of output pulse.

Reset to Zero

Accomplished by negative pulse or voltage level change. Reset line held at 0 volts. At reset, line is driven to -10 volts for 1 microsecond, minimum.

Power Requirements

100 ma at -15 volts and 17 ma at +10 volts.

Operating Temperature

-55^{o} C to $+75^{o}$ C.

Construction

Etched wire module with circuitry on both sides using "plated-through" component holes.

Transistors

Eight 2N961, one 2N835, and one 2N1143, soldered into circuit.

Dimensions

1/2 inch wide, 3-11/16 inches high, 3-5/32 inches deep.

Weight

1-3/4 oz.

Connector Required

Typical: Ucinite 119510-MC-15C. Beckman 680-815353.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU plugs into a 15-pin printed circuit card connector. Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

The unit operates with supply voltages of -15 volts and +10 volts. The negative voltage supply connects to pin K of the DCU connector, while the positive supply connects to pin J.

2.3 SUPPLYING INPUT SIGNALS

Connect the source of input signals to pin A of the DCU connector. The unit will register a count each time a pulse meeting the requirements listed in Section 1.2, Input Requirements, is applied to the input terminal.

2.4 STATE OF THE BINARIES

At the collectors of the "normally-on" transistors, -6.0 volts indicates the corresponding binary is in the "one" state, while -0.2 volts represents the "zero" state. Table 1 indicates the binary states for each registered count from 0 to 9.

Use Table 1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weights. For example, the coded digit "1100" is equivalent to 1+2+0+0 = 3; and "1001" is equivalent to 1+0+0+8 = 9.

2.5 USING OUTPUT SIGNALS

The unit provides readout signals in the form of high and low potentials at terminals D, F, M, and P of the DCU connector. These signals can be used to drive any external load within the specifications listed in Section 1.2, Output Characteristics.

For example, the readout signals at terminals D, F, M, and P can be used to drive an Electroluminescent Storage Unit for a visual indication of the registered count. In addition, the output signal supplied to terminal R each time the count goes from 9 to 0 can drive a Model 860 DCU, another Model 870 DCU, or other circuitry.

Table 1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

2.6 RESETTING UNIT TO ZERO

While counting, the reset line (terminal L) must be clamped at 0 volts. Applying a 1 μsecond, -10 volt pulse to terminal L of the DCU will effect reset. The reset voltage can be generated either electronically by transistor circuitry or mechanically through relay contacts.

SECTION 3

CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of p-n-p transistors, connected in a scale-to-ten circuit. The binaries have two stable states and are alternately triggered from one state to the other by successive pulses. Transistors Q9 and Q10 are emitter followers to isolate the first and fourth binaries, respectively, from their ac load.

In a p-n-p transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Therefore, no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input pulse applied through diode CR3 to the base of Q2 drives this transistor to cutoff.

The pulse applied to CR3 is also applied to CR2, but does not affect the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, its collector potential approaches -6 volts. This change in voltage level, coupled through resistor R5 and capacitor C4 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R2 causes the collector potential to fall to almost zero. Under these conditions the diode base clamp CR5 with divider network R4 and R7 maintains a positive potential at the base of Q2 to keep it cut off.

The binary, now in the "one" state, remains in this stable state until the next positive input pulse arrives. At that time, Q1 cuts off, Q2 conducts, and the binary resumes its original state.

The collector of each "normally off" transistor in the four binaries connects to a corresponding terminal of the DCU connector. Thus, the change in voltage level at each collector, as the binary changes state, is available as an output signal. The change in voltage level at the collector of each "normally on" transistor is used as the drive signal to the next binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 870 DCU is a four-place binary counter wired so that it resets to zero on every tenth input pulse. Operation is explained in detail in the following paragraphs.

3.2.1 Initial Conditions and Circuit Fundamentals

Under initial conditions, transistors Q2, Q4, Q6, and Q8 are saturated. Transistors Q1, Q3, Q5, and Q7 are cut off. These conditions define the "zero" state for each binary.

At this point, a review of transistor binary (flip-flop) circuit fundamentals may be helpful in understanding the circuit description in the following paragraphs.

Consider the first binary, comprising transistors Q1 and Q2. Under initial conditions, Q1 is cut off and Q2 is saturated. Q1 is held at cutoff by divider network R5, R6 and clamp CR4. A positive input pulse applied at the junction of CR2 and CR3 has no effect on Q1, since it is already cut off. While Q2 is saturated, its collector is near ground potential. Now, when the positive input pulse is applied through CR3 to the base of Q2, it drives Q2 into cutoff and the collector potential of Q2 rises to approximately -6 volts. This negative transient, coupled to the base of Q1 through crossover network R5 and C4, drives Q1 into saturation.

Thus, on the first input pulse, the first binary flips and its transistors reverse their states. But the second binary is not affected, since it takes a positive output pulse coupled through emitter follower Q9 from the first binary to cause the second binary to flip.

But on application of the second input pulse, circuit action produces a positive output signal to flip the second binary as follows: the positive input pulse goes through CR2 to the base of Q1 to cut it off. As Q1 cuts off, its collector potential rises to approximately -6 volts. This negative transient couples to the base of Q2 through crossover network R4 and C3 driving it into saturation. When Q2 saturates, the collector potential goes from approximately -6 volts to approximately -0.2 volt. This positive-going pulse passes through emitter follower Q9 to trigger the second binary. To summarize: a positive pulse applied to the first binary will cutoff the saturated transistor, and regenerative action will drive the cut off transistor into saturation. The first binary will produce a driving pulse to the second binary only when the second transistor of the first binary goes from cutoff to saturation. Thus, the first binary will produce an output pulse only on every second input pulse, even though every input pulse will reverse the state of the binary. These principles apply to all of the binaries.

3.2.2 Sequence of Operation

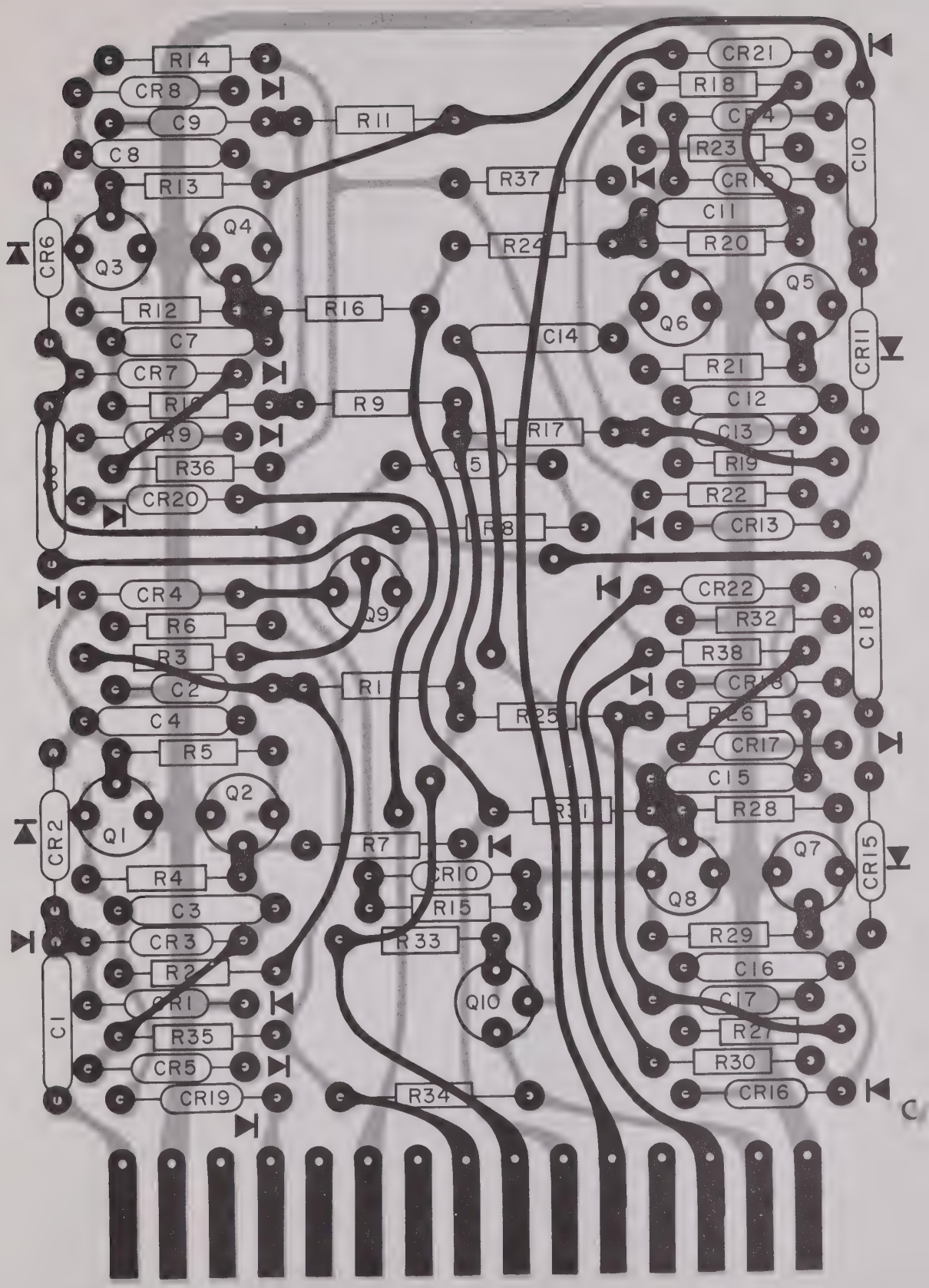
PULSE NO.	ACTION
1	First binary flips. Q2 turns off. No output signal.
2	First binary flips. Q2 saturates. Output pulse coupled through Q9 flips second binary. Q4 turns off.
3	First binary flips. Q2 turns off. No output signal.
4	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary and Q6 cuts off.
5	First binary flips. Q2 turns off. No output signal.
6	First binary flips. Q2 saturates. Output signal from Q2 flips second binary. Q4 turns off. No output pulse from Q4.
7	First binary flips. No output from Q2.
8	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary. Q6 saturates. Output pulse from Q6 flips fourth binary. Q8 cuts off. Negative 6.5 volts at collector of Q8 is applied CR6 and CR7 closing the gate.
9	First binary flips. No output from Q2.
10	First binary flips. Q2 saturates. Output signal from Q2 is blocked from the second binary by closed gate CR6 and CR7. So it goes through C18 and CR15 to flip the fourth binary. Q8 saturates. The output pulse from Q8 goes through emitter follower Q10 to DCU output pin R.

3.2.3 Summary

At the tenth input pulse, all four binaries are in the "zero" state and the DCU is ready for the next counting cycle. The positive output signal from transistor Q10, produced when the counter goes from nine to zero, can be used to drive a Model 860 DCU or another Model 870 DCU. Thus, the counter will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded decimal form by the potentials on the readout lines of the binaries.

The reset line connects through a corresponding resistor to the base of the normally-on transistor (Q2, Q4, Q6, and Q8) in each binary. A negative voltage pulse applied to the reset line will cause the normally-on transistors to conduct and thus trigger all binaries to the zero state.



63-B-36

MODEL 870 DCU COMPONENT LAYOUT

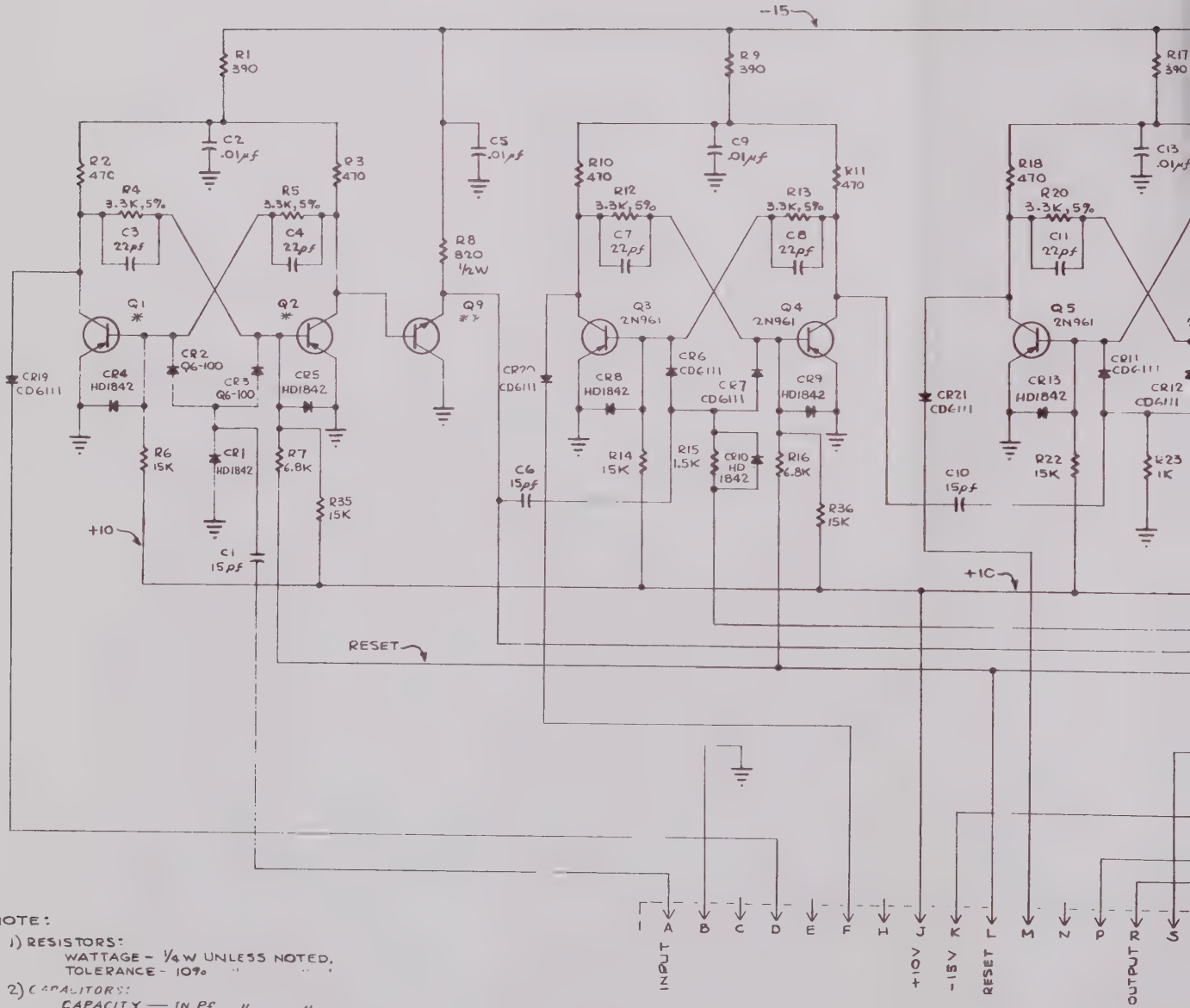
SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	637-824006	Capacitor, F. Mica, 15pf, 300V, 5%	4
C2	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	5
C3	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	8
C4		Same as C3	
C5		Same as C2	
C6		Same as C1	
C7 & C8		Same as C3	
C9		Same as C2	
C10		Same as C1	
C11 & C12		Same as C3	
C13		Same as C2	
C14	637-824004	Capacitor, F. Mica, 10pf, 300V, 5%	1
C15 & C16		Same as C3	
C17		Same as C2	
C18		Same as C1	
CR1	755-824300	Diode, Germanium, type HD1842	11
CR2	755-817250	Diode, Germanium, 6 PIV, 200 ma, 1V min. fwd.	3
CR3		Same as CR2	
CR4 & CR5		Same as CR1	
CR6	755-815561	Diode, Silicon, 75 PIV, 10 ma, 1V min. fwd.	8
CR7		Same as CR6	
CR8 thru CR10		Same as CR1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
CR11 & CR12		Same as CR6	
CR13 & CR14		Same as CR1	
CR15		Same as CR2	
CR16 thru CR18		Same as CR1	
CR19 thru CR22		Same as CR6	
Q1	755-415036	Transistor, Germanium, PNP, special	2
Q2		Same as Q1	
Q3	755-817811	Transistor, Germanium, PNP, 150mw	6
Q4 thru Q8		Same as Q1	
Q9	755-419596	Transistor, Special	
Q10	755-823145	Transistor, Germanium, PNP, 300mw max.	1
R1	601-823104	Resistor, F. Comp., 390Ω, 1/4W, 10%	5
R2	601-823105	Resistor, F. Comp., 470Ω, 1/4W, 10%	8
R3		Same as R2	
R4	601-822296	Resistor, F. Comp., 3.3K, 1/4W, 5%	8
R5		Same as R4	
R6	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	8
R7	601-823945	Resistor, F. Comp., 6.8K, 1/4W, 10%	4
R8	601-008075	Resistor, F. Comp., 820Ω, 1/2W, 10%	1
R9		Same as R1	
R10 & R11		Same as R2	
R12 & R13		Same as R4	
R14		Same as R6	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R15	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	2
R16		Same as R7	
R17		Same as R1	
R18 & R19		Same as R2	
R20 & R21		Same as R4	
R22		Same as R6	
R23	601-823111	Resistor, F. Comp., 1K, 1/4W, 10%	1
R24		Same as R7	
R25		Same as R1	
R26 & R27		Same as R2	
R28 & R29		Same as R4	
R30		Same as R6	
R31		Same as R7	
R32		Same as R15	
R33		Same as R1	
R34	601-008076	Resistor, F. Comp., 1K, 1/2W, 10%	1
R35 thru R38		Same as R6	
	864-412958	Pad, Transistor	10



NOTE:

1) RESISTORS:
   WATTAGE - 1/4 W UNLESS NOTED,
   TOLERANCE - 10% " " "

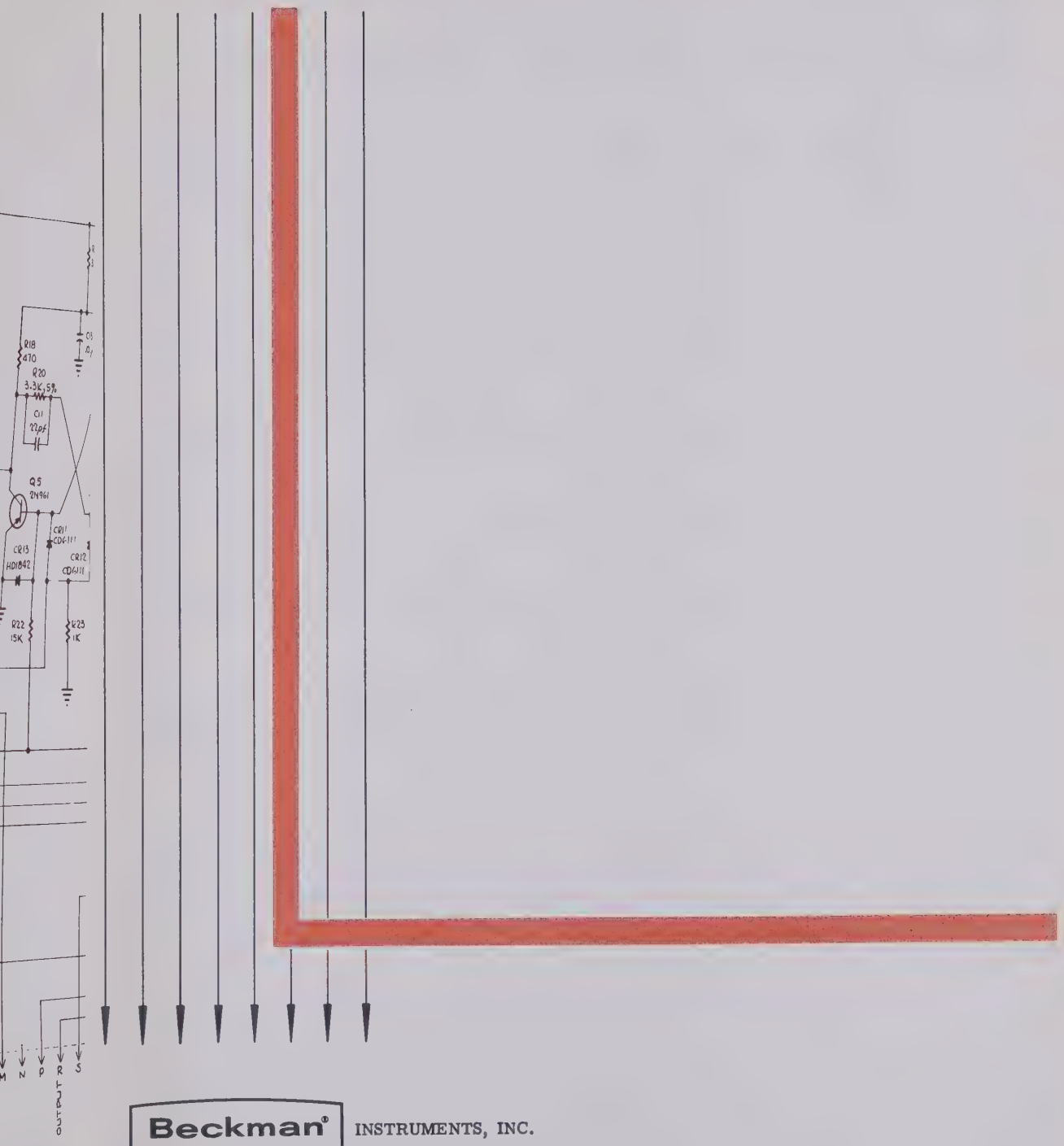
2) CAPACITORS:
   CAPACITY — IN Pf, " " ,
   VOLTAGE — 300 v., " " ,
   TOLERANCE — 5 % , " " ,
   .01μf DISC ARE -20+80%, 500v.

3) * TRANSISTORS ARE BECKMAN SPEC. 755-415036.

4) ** TRANSISTORS ARE BECKMAN SPEC. 755-415506.

INSTRUCTION MANUAL

MODEL 860
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

December 1962

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(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

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CONTENTS

		Page
SEC. 1	INTRODUCTION	
	1.1 General Description	1-1
	1.2 Technical Characteristics	1-1
SEC. 2	OPERATION	
	2.1 Mounting the Unit	2-1
	2.2 Supplying Power	2-1
	2.3 Supplying Input Signals	2-1
	2.4 Using Output Signals	2-1
	2.5 Resetting Counter to Zero	2-2
SEC. 3	CIRCUITS	
	3.1 The Binaries	3-1
	3.2 The Scale-of-Ten Circuit	3-2
SEC. 4	PARTS LIST	

DIAGRAMS

Model 860 DCU Component Layout 3-5

Model 860 DCU Schematic Diagram (D411932-Rev. B)

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 860 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit provides a count of input pulses from zero to nine, each count being represented by output signals in binary (1-2-4-8) coded decimal form. With an Electroluminscent Storage Unit this binary-coded output can be converted into a decimal digit display of the registered count.

At every tenth input pulse, the DCU generates an output signal suitable to drive a Model 850 or a Model 860 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 TECHNICAL CHARACTERISTICS

Count Indication

Binary-coded decimal (1-2-4-8) electrical signals.

Input Requirements

Positive pulse or voltage step, 6 volts to 8 volts amplitude (+7.0 recommended), 10 nanoseconds rise-time. Pulse duration 30 nanoseconds, minimum.

Counting Rate

2.5 megacycles, maximum

Output Characteristics

1-2-4-8 permuted binary code

Output available from one side of each binary. Voltage levels -0.2 volts and -13.0 volts. Binaries designed to drive maximum of 2 ma through 7.5 K to the negative supply of -15 volts.

Carry pulse output designed to drive a following Model 860 DCU or Model 850 DCU.

Designed to drive 1.5 ma into Electroluminescent Storage Unit from "off" side of binaries.

Reset Requirements

Negative pulse or voltage level change. Reset time held at 0 volts. At reset, line is driven to -10 volts for 10 microseconds.

Power Requirements

45 ma at -15 volts and 4.0 ma at +10 volts.

Transfer Time

100 nanoseconds between application of tenth input pulse and start of output pulse.

Transistors

Germanium, two 2N960 and six 2N968. Soldered into circuit.

Demensions

1/2 inch wide, 3-11/16 inches high, 3-5/32 inches deep.

Weight

1-1/2 oz.

Connector Required

UCINITE 119510-MP-15C. Beckman 20N 680 815353.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU plugs into a 15-pin printed-card connector. Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

Ordinarily, the unit operates with supply voltages of -15 volts and +10 volts. The negative voltage supply connects to pin K of the DCU connector, and the positive supply to pin J. Supply voltage tolerance ±10%.

2.3 SUPPLYING INPUT SIGNALS

Connect the input signal to pin C of the DCU connector. The unit registers a count each time a pulse +6 to +8 volts in amplitude (with a minimum width of 30 nanoseconds and a 10 nanoseconds rise time) is applied to the input terminal.

Pin A (capacitor bypass) provides an alternate input. If used, this input should be driven through an external capacitor.

2.4 USING OUTPUT SIGNALS

Each of the DCU's four binaries supply readout signals in two forms: with a B- supply of -15 volts, -0.3 volts with respect to ground (pin S) for a binary "one", and -12 volts with respect to ground for a binary "zero". The binary states of "one" or "zero" indicate the registered count in 1-2-4-8 binary coded decimal. Each readout line will supply a maximum steady state current of 2 ma into a load connected to B-. Table 1 represents the binary state for each registered count from 0 to 9.

The readout signals at terminals D, F, M, and P, can be used to drive the Electroluminescent Storage Unit for a visual indication of the registered count. In addition, the output signal produced at terminal R each time the count goes from 9 to 0 can drive either a Model 850 or 860 DCU or other circuitry.

Table 1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

The readout signals at terminals D, F, M and P drive an Electroluminescent Storage Unit for a visual indication of the registered count. In addition, the output signal produced at terminal R each time the count goes from 9 to 0 can be used to drive another Model 850 DCU or other circuitry.

2.5 RESETTING DCU TO ZERO

Reset lines H, L, and N are clamped at zero volts while the DCU counts. A negative pulse to lines H and L (line N clamped at zero volts) will reset the DCU to zero. The DCU can be set to 9 by applying a negative pulse to lines L and N (line H clamped at zero volts). A 10 microsecond, -10 volt pulse will reset the DCU. The reset pulse can be generated either electronically by transistor circuitry or mechanically through relay contacts.

SECTION 3
CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of p-n-p transistors, connected in a scale-of-ten circuit. The binaries have two stable states and are alternately triggered from one state to the other by successive input pulses.

In a p-n-p transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Consequently no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input pulse applied through diode CR4 to the base of Q2 drives this transistor to cutoff.

The pulse applied to CR1 and CR4 has no effect on the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, the potential on its collector approaches B-. This change in voltage level, coupled through resistor R10 and capacitor C2 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R1 causes the potential on the collector to fall to almost zero. Under these conditions, the diode base clamp CR3 combined with the divider network R11 and R21 maintains a positive potential at the base of Q2 to keep it cut off.

The binary, now in the "one" state, remains in this stable state until the next positive input pulse arrives. At that time, Q1 cuts off, Q2 conducts, and the binary resumes its original state.

The collector of each "normally off" transistor in the four binaries connects to a corresponding terminal of the DCU connector. Thus, the change in voltage level at each collector, as the binary changes state, is available as an output signal. The change in voltage level at the collector of each "normally on" transistor is used as the drive signal to the next binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 860 DCU is a four-place binary counter wired so that it resets to zero on every tenth input pulse. Operation is explained in detail in the following paragraphs.

3.2.1 Initial Conditions and Circuit Fundamentals

Under initial conditions, transistors Q2, Q4, Q6, and Q8 are saturated. Transistors Q1, Q3, Q5, and Q7 are cut off. These conditions define the "zero" state for each binary.

At this point, a review of transistor binary (flip-flop) circuit fundamentals may be helpful in understanding the circuit description in the following paragraphs.

Consider the first binary, transistors Q1 and Q2. Under initial conditions, Q1 is cut off and Q2 is saturated. Transistor Q1 is held at cutoff by divider network R18, R10, and clamp CR1. A positive input pulse applied at the junction of C10 and CR1, has no effect on Q1, since it is already cut off. While Q2 is saturated, its collector is near ground potential. Now, when the positive input pulse is applied through CR4 to the base of Q2, it drives Q2 into cutoff and the collector potential rises to approximately -12 volts. This negative transient, coupled to the base of Q1 through crossover network R10 and C2, drives Q1 into saturation.

Thus, on the first input pulse, the first binary "flips" and its transistors reverse their states. But the second binary is not affected since it takes a positive output pulse from the binary to cause the second binary to flip.

But on application of the second input pulse, circuit action produces a positive output signal to flip the second binary, as follows: the positive input pulse goes through C10 to the base of Q1 to cut it off. As Q1 cuts off, its collector potential rises to approximately -12 volts. This negative transient, coupled to the base of Q2 through crossover network R11 and C3, drives Q2 into saturation. When Q2 saturates, the collector potential goes from approximately -12 volts to approximately -0.2 volts. This positive-going pulse passes through C11 and CR6 to trigger the second binary. To summarize: a positive pulse applied to the first binary will cut off the saturated transistor, and regenerative action will drive the cut off transistor into saturation. The first binary will produce a driving pulse to the second binary only when the second transistor of the first binary goes from cutoff to saturation. Thus, the first binary will produce an output pulse only on every second input pulse, even though every input pulse will reverse the state of the binary. These principles apply to all of the binaries.

3.2.2 Sequence of Operation

PULSE NO.	ACTION
1	First binary flips. Q2 turns off. No output signal.
2	First binary flips. Q2 saturates. Output pulse flips second binary. Q4 turns off.
3	First binary flips. Q2 turns off. No output signal.
4	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary and Q6 cuts off.
5	First binary flips. Q2 turns off. No output pulse from Q2.
6	First binary flips. Q2 saturates. Output signal from Q2 flips second binary. Q4 turns off. No output pulse from Q4.
7	First binary flips. No output signal from Q2.
8	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary. Q6 saturates. Output pulse from Q6 flips fourth binary. Q8 cuts off. Negative 12 volts at collector of Q8 is applied to CR 9 and CR6 closing the gate.
9	First binary flips. No output from Q2.
10	First binary flips. Q2 saturates. Output signal from Q2 is blocked from second binary by closed gate CR9 and CR6. So it goes through C14 and CR9 to flip the fourth binary. Q8 saturates. The output pulse from Q8 goes to DCU output pin R.

3.2.3 Summary

At the tenth input pulse, all four binaries are in the "zero" state and the DCU is ready for the next counting cycle. The positive output signal from transistor Q8, produced when the counter goes from nine to zero, can drive a Model 860 or 850 DCU. Thus, the counter will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded decimal form by the potentials on the readout line of the binaries.

Reset lines H and L connect through corresponding resistors to the base of the normally-on transistors (Q2, Q4, Q6, and Q8) in each binary. A negative voltage pulse applied to these reset lines will cause the normally-on transistors to conduct and trigger all binaries to the zero state.

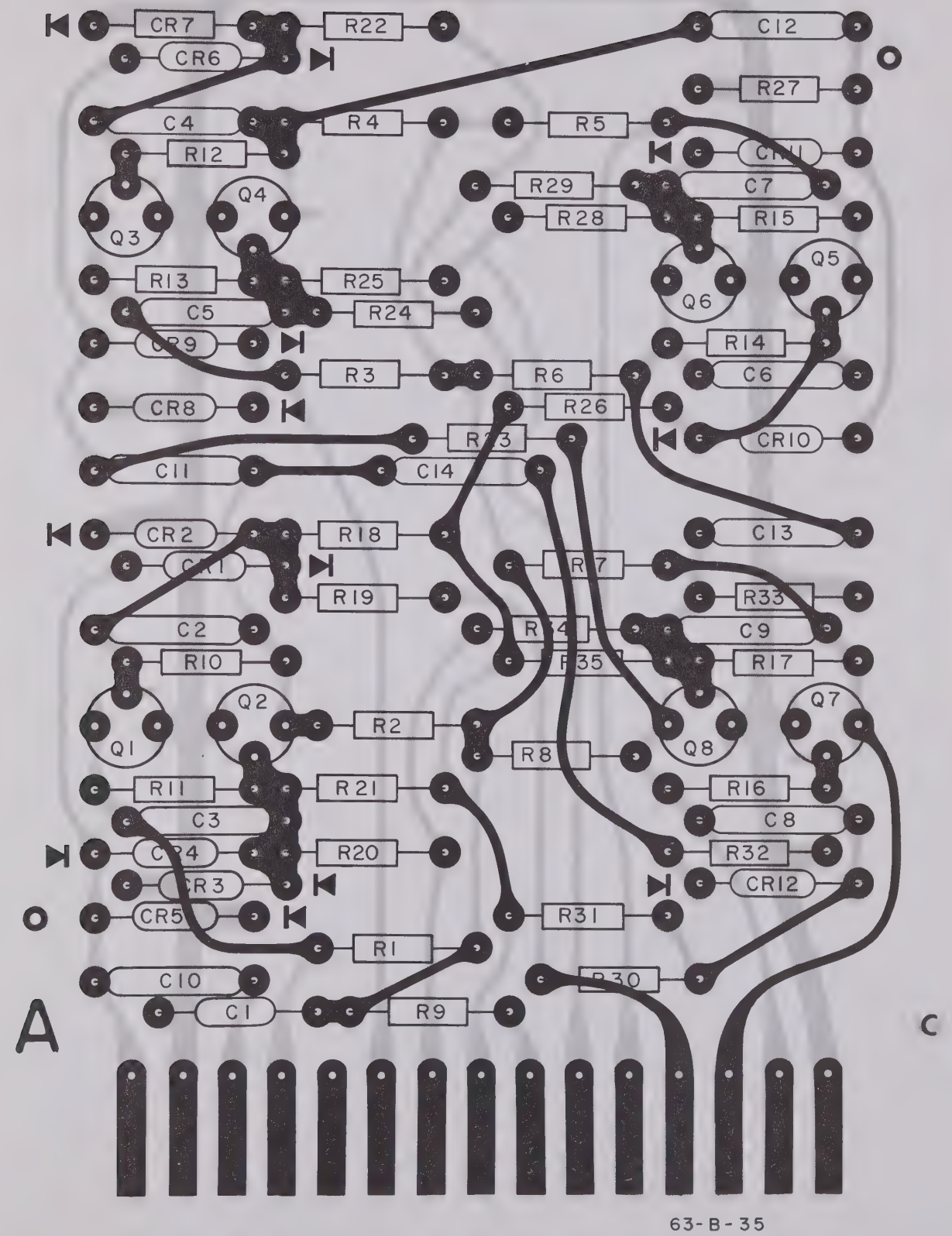
Reset line N connects through a corresponding resistor to the base of the normally-off transistors Q1 and Q7. When a negative pulse is applied to line N, transistors Q1 and Q7 are turned on setting the 1st and 4th binaries to the "one" state. Applying a reset pulse to lines N and L simultaneously will set the DCU to the binary state of "1001", which is equivalent to 9.

SECTION 4

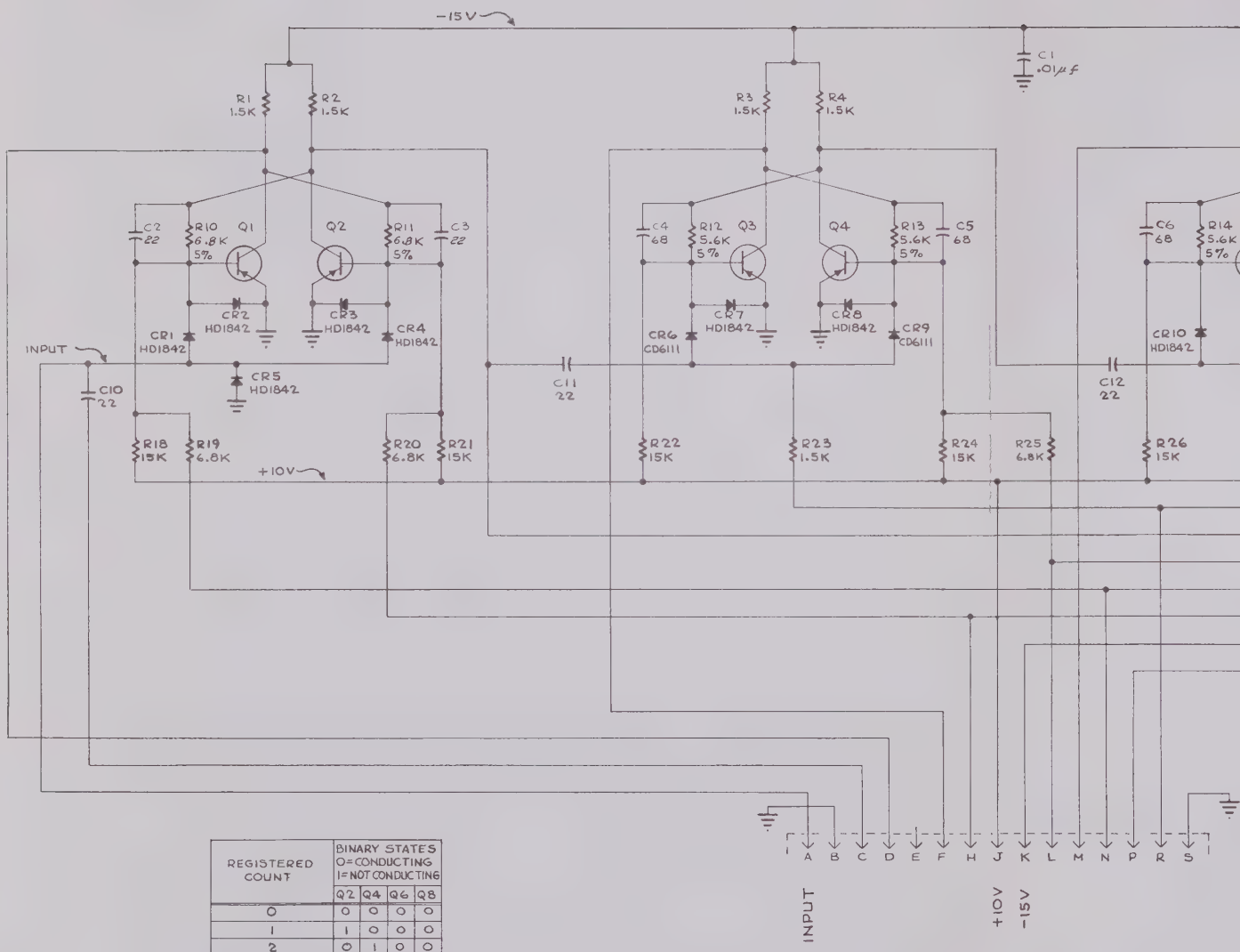
PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	1
C2	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	7
C3		Same as C2	
C4	637-824014	Capacitor, F. Mica, 68pf, 300V, 5%	6
C5 thru C9		Same as C4	
C10 thru C14		Same as C2	
CR1	755-824300	Diode, Germanium, type HD1842	10
CR2 thru CR5		Same as CR1	
CR6	755-815561	Diode, Silicon, 75PIV, 10 ma, 1V min. fwd.	2
CR7 & CR8		Same as CR1	
CR9		Same as CR6	
CR10 thru CR12		Same as CR1	
Q1	755-824880	Transistor, Germanium, PNP, 150mw	2
Q2		Same as Q1	
Q3	755-817587	Transistor, Germanium, PNP, 150mw	6
Q4 thru Q8		Same as Q3	
R1	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	12
R2 thru R8		Same as R1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R9	601-823917	Resistor, F. Comp., 10Ω, 1/4W, 10%	1
R10	601-822299	Resistor, F. Comp., 6.8K, 1/4W, 5%	2
R11		Same as R10	
R12	601-822397	Resistor, F. Comp., 5.6K, 1/4W, 5%	6
R13 thru R17		Same as R12	
R18	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	8
R19	601-823945	Resistor, F. Comp., 6.8K, 1/4W, 10%	6
R20		Same as R19	
R21 & R22		Same as R18	
R23		Same as R1	
R24		Same as R18	
R25		Same as R19	
R26		Same as R18	
R27		Same as R1	
R28		Same as R19	
R29		Same as R18	
R30		Same as R19	
R31		Same as R18	
R32 & R33		Same as R1	
R34		Same as R19	
R35		Same as R18	
	864-412958	Pad, Transistor	8



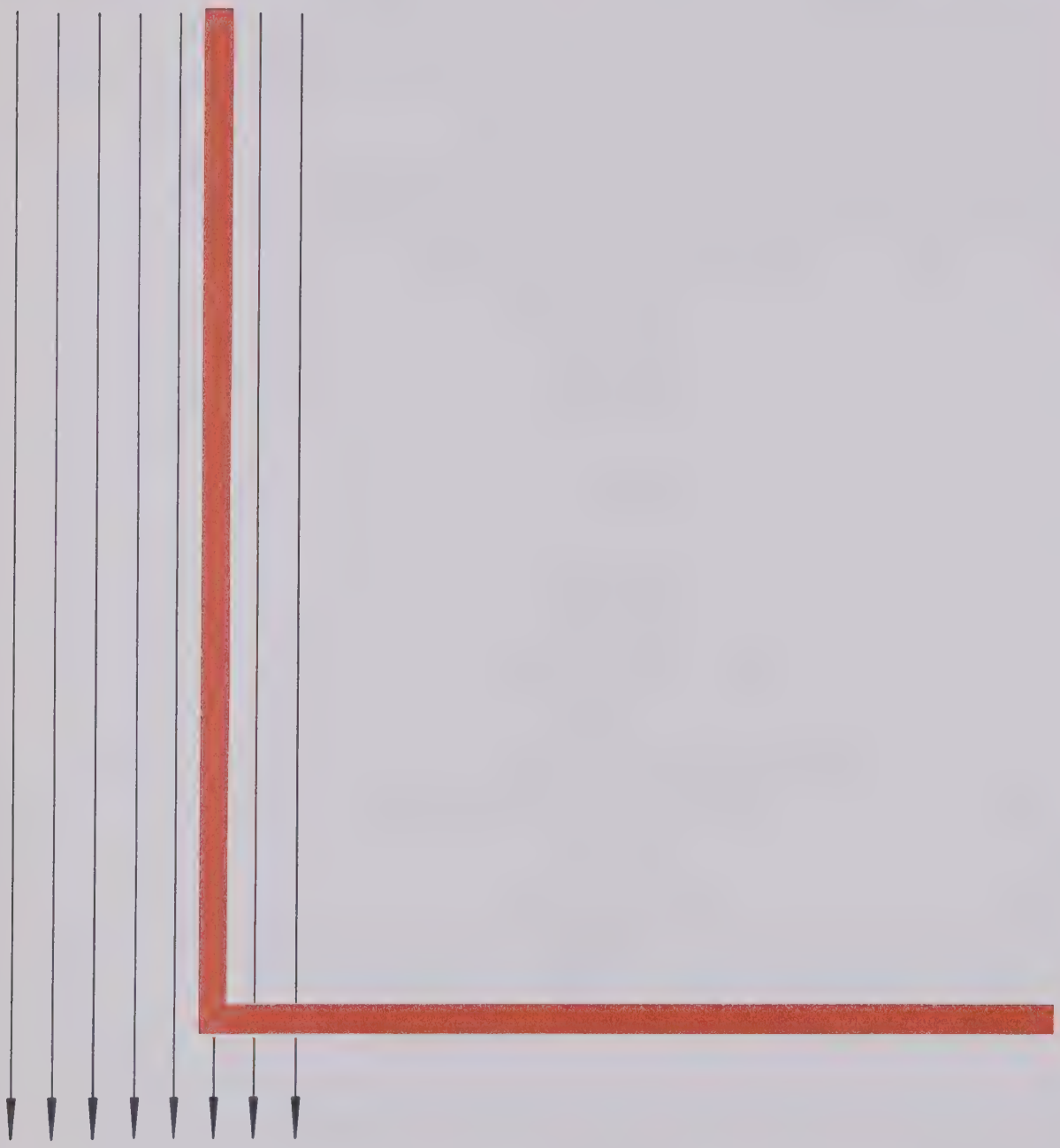
MODEL 860 DCU COMPONENT LAYOUT



REGISTERED COUNT	BINARY STATES 0=CONDUCTING 1=NOT CONDUCTING			
	Q2	Q4	Q6	Q8
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

INSTRUCTION MANUAL

DATA STORAGE UNIT



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

November 1964

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

CONTENTS

		Page
SEC. 1	INTRODUCTION	
	1.1 General	1-1
	1.2 Specifications	1-1
SEC. 2	OPERATION	
	2.1 Installing the Data Storage Unit	2-1
	2.2 Input Requirements	2-1
	2.3 Output Characteristics	2-1
SEC. 3	CIRCUITS	
	3.1 Basic Circuits	3-1
	3.2 The Storage Circuit	3-1
SEC. 4	PARTS LIST	4-1

ILLUSTRATIONS

Figure		
2-1	Data Storage Unit Plug-in Printed Circuit Board	2-1
3-1	Flow Diagram of Data Storage Unit	3-1
3-2	A Typical Storage Binary in the "0" State	3-2
3-3	Stages in the Transition of a Binary From the "0" State to the "1" State	3-3
3-4	Partial Schematic Indicating Lamp Control Logic	3-4
3-5	The Basic Photoconductor Switching Circuit in Its Two States	3-5

DIAGRAMS

Data Storage Unit Decoder Block	62-D-88
Data Storage Unit Schematic	D410532 - Rev. D
Data Storage Unit Component Layout	63-C-8

SECTION 4
PARTS LIST

SECTION 1
INTRODUCTION

1.1 GENERAL

The Data Storage Unit (DSU) stores binary coded information received from a decimal counting unit (DCU) such as Beckman Model 850, 860, or 870, and displays this information on a separate electroluminescent readout. Upon command, the DSU converts binary information into a decimal equivalent. The DSU comprises a plug-in printed circuit board using all solid-state components.

1.2 SPECIFICATIONS

Table 1-1. Main Characteristics

COUNT DISPLAY	In-line digit on Sylvania Series NU-50 Electroluminescent panel (separate from DSU)
DISPLAY CONTROL OUTPUTS	Segment off: 50 volts p-p (typical) Segment on: 900 volts p-p (typical)
INPUT REQUIREMENTS (from DCU)	Binary "1" -6 volts Binary "0" -0.3 volts
CLEAR PULSE	-10 volts, 5 μs duration
SET PULSE	-10 volts, 5 μs duration
POWER REQUIREMENTS	B+ +105 volts at 10 ma +10 volts at 2 ma B- -15 volts at 23 ma Display 900 volts p-p, 500 cps
DIMENSIONS	6.56 inches by 4.09 inches
WEIGHT	5.3 oz.
MOUNTING	Two 15-pin P. C. Board Connectors

SECTION 2
OPERATION

2.1 INSTALLING THE DSU

The DSU plugs into two 15-pin printed card connectors.

2.2 INPUT REQUIREMENTS

Table 1-1 summarizes the input requirements of the DSU.

2.3 OUTPUT CHARACTERISTICS

2.3.1 Display Control Output

For each decimal digit (0 through 9) registered, a decoder in the DSU generates a combination of on/off voltages to control segments of a Sylvania series NU-50 electroluminescent display. Typical voltages are 50 volts peak-to-peak to extinguish a segment, and 900 volts peak-to-peak to light a segment.

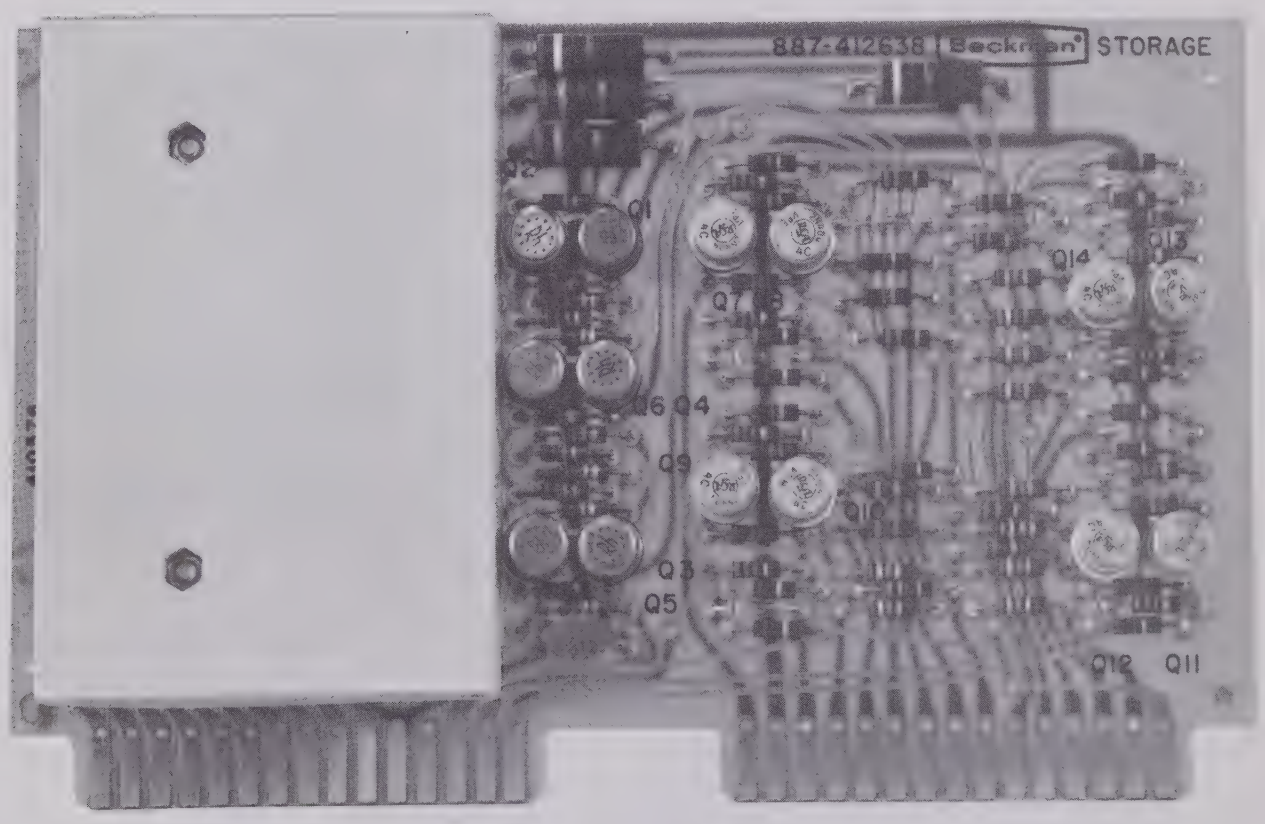


FIG. 2-1. Data Storage Unit Plug-in Printed Circuit Board

SECTION 3
CIRCUITS

3.1 BASIC CIRCUITS

As shown in Figure 3-1, the DSU comprises a storage and decoding circuit with a separate digital display. Section 3.2 describes the storage circuit, a set of four binary (flip-flop) stages. Section 3.3 explains how the decoding logic converts the stable states of the binaries into seven lines of display control information.

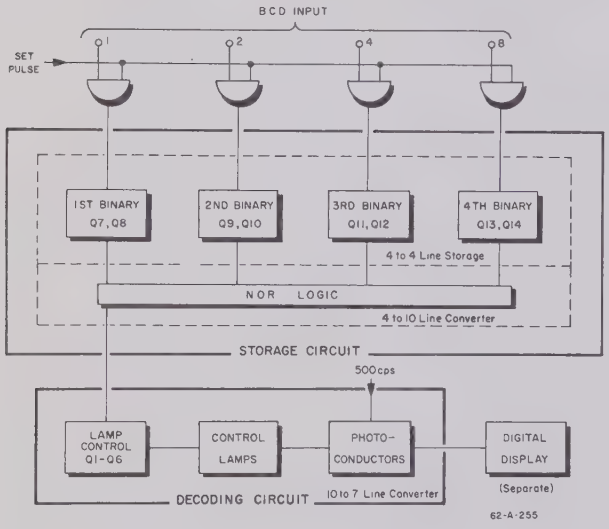


FIG. 3-1. Flow Diagram of Data Storage Unit

3.2 THE STORAGE CIRCUIT

Four binaries make up the storage circuit. Each binary comprises a pair of p-n-p transistors with the collector of each transistor directly coupled to the base of the other. Being symmetrical, the circuit can exist in either of two stable states: one transistor is cut off (OFF), and the other is conducting (ON).

In a p-n-p transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. Conversely, a positive base potential results in a high input impedance (several hundred thousand ohms); therefore, no base current flows and the transistor is cut OFF.

Figure 3-2 shows a typical binary in the "0", or clear, state (Q7 ON, Q8 OFF) and explains how the circuit stabilizes itself in that state.

With a negative voltage applied to the input terminal and a negative set pulse to R76, the binary changes states by a process described in Figure 3-3. During the change, the collector voltage of one transistor drops sharply while the other rises. These collector voltage swings drive transistors Q1-Q6 to provide the logic needed in converting the stable states of the four binaries into seven lines of display control information.

Driven by the storage binaries, transistors Q1-Q6 control the neon lamps. Depending on the ON-OFF combination of transistors Q1-Q6, neon lamps DS1 - DS15 light in appropriate combinations to provide the logic needed to control the electroluminescent segments.

Two conditions must exist before a neon lamp will light: enough potential to "fire" the lamp, and a complete current path. These two conditions are met by the ON-OFF combination of transistors Q1-Q6. Transistors Q3-Q6 act as switches to complete the current path for the lamps, while Q1 and Q2 set the potential for firing the correct lamps. Together, Q1-Q6 form the neon lamp control circuit.

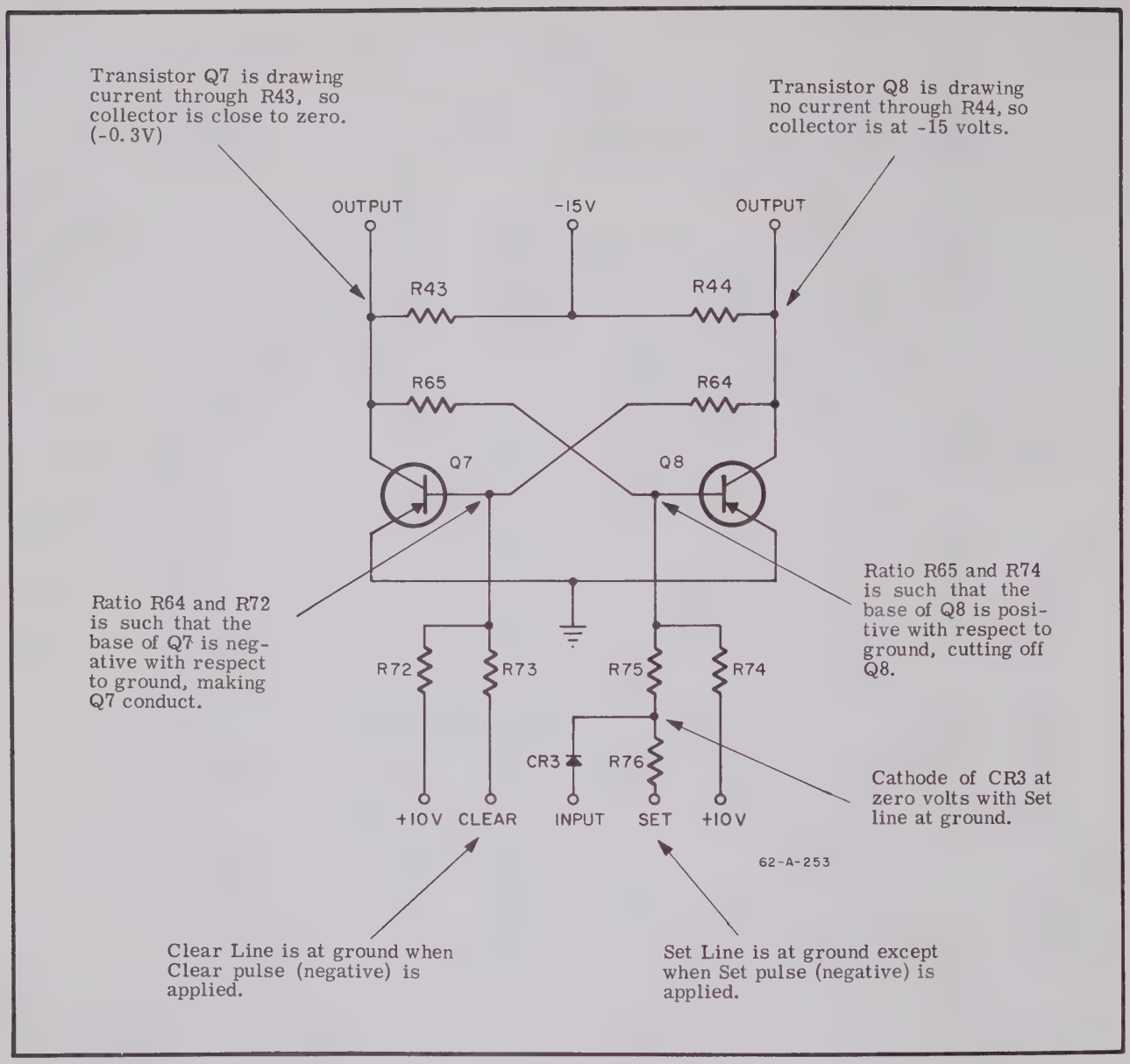

Transistor Q7 is drawing current through R43, so collector is close to zero. (-0.3V)
Transistor Q8 is drawing no current through R44, so collector is at -15 volts.
OUTPUT
-15V
OUTPUT
R43
R44
R65
R64
Q7
Q8
Ratio R64 and R72 is such that the base of Q7 is negative with respect to ground, making Q7 conduct.
Ratio R65 and R74 is such that the base of Q8 is positive with respect to ground, cutting off Q8.
R72
R73
R75
R74
CR3
R76
Cathode of CR3 at zero volts with Set line at ground.
+10V
CLEAR
INPUT
SET
+10V
62-A-253
Clear Line is at ground when Clear pulse (negative) is applied.
Set Line is at ground except when Set pulse (negative) is applied.

FIG. 3-2. A Typical Storage Binary in the "0" State

Figure 3-4 shows in simplified form the logic used to control the lamps. As shown, the storage binaries drive the lamp control circuits. When the storage binaries set, the lamp control transistors follow by either turning ON or OFF (Q1 normally ON, Q2-Q6 normally OFF in clear state).

The neon control circuits use n-p-n transistors instead of p-n-p transistors as in the storage binaries. Unlike the p-n-p transistor, the n-p-n transistor requires a positive voltage to turn it ON, and a negative voltage to turn if OFF. For example, assume these conditions exist using Figure 3-4 as a guide: Q2, Q3 and Q5 ON, Q1

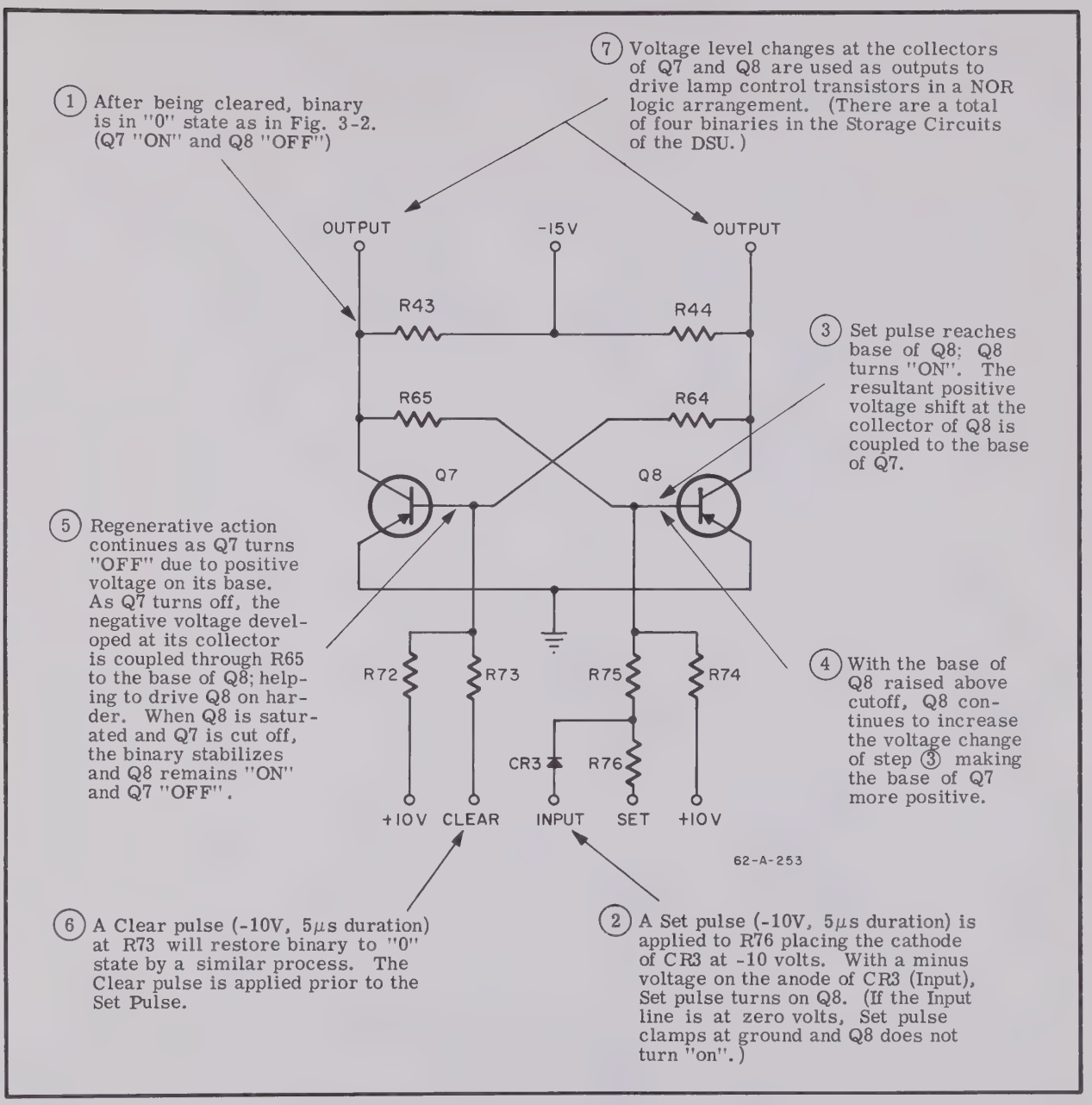

7 Voltage level changes at the collectors of Q7 and Q8 are used as outputs to drive lamp control transistors in a NOR logic arrangement. (There are a total of four binaries in the Storage Circuits of the DSU.)
1 After being cleared, binary is in "0" state as in Fig. 3-2. (Q7 "ON" and Q8 "OFF")
OUTPUT
-15V
OUTPUT
R43
R44
3 Set pulse reaches base of Q8; Q8 turns "ON". The resultant positive voltage shift at the collector of Q8 is coupled to the base of Q7.
R65
R64
Q7
Q8
5 Regenerative action continues as Q7 turns "OFF" due to positive voltage on its base. As Q7 turns off, the negative voltage developed at its collector is coupled through R65 to the base of Q8; helping to drive Q8 on harder. When Q8 is saturated and Q7 is cut off, the binary stabilizes and Q8 remains "ON" and Q7 "OFF".
R72
R73
R75
R74
4 With the base of Q8 raised above cutoff, Q8 continues to increase the voltage change of step 3 making the base of Q7 more positive.
CR3
R76
+10V
CLEAR
INPUT
SET
+10V
62-A-253
6 A Clear pulse (-10V, 5μs duration) at R73 will restore binary to "0" state by a similar process. The Clear pulse is applied prior to the Set Pulse.
2 A Set pulse (-10V, 5μs duration) is applied to R76 placing the cathode of CR3 at -10 volts. With a minus voltage on the anode of CR3 (Input), Set pulse turns on Q8. (If the Input line is at zero volts, Set pulse clamps at ground and Q8 does not turn "on".)

FIG. 3-3. Stages in the Transition of a Binary From the "0" State to the "1" State

OFF. With Q2 on, a voltage drop appears across R10 reducing the potential on DS1 and DS2 below the ignition point, even though Q3 is ON establishing a current path. But DS4 will fire since one side is tied to +110 volts and Q3 provides a current path.

Since Q1 is off, no voltage drop appears across R9. Lamps DS8 and DS9 can fire since Q5 is ON completing the current path. Note also that the collector of Q10 and the base of Q5 are tied together through R51 to form the NOR logic. If a positive voltage appears across R50 and turns

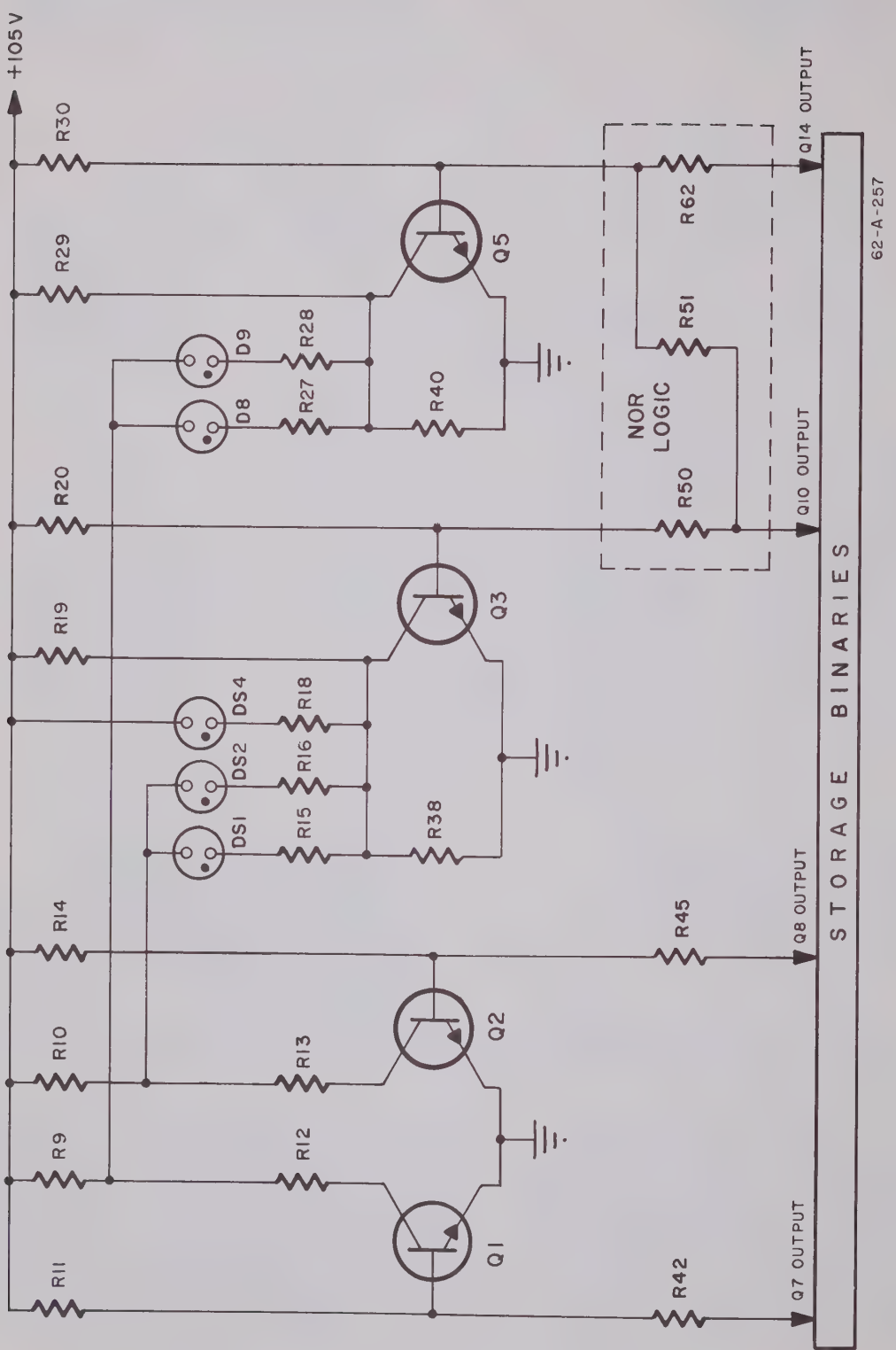


FIG. 3-4. Partial Schematic Indicating Lamp Control Logic

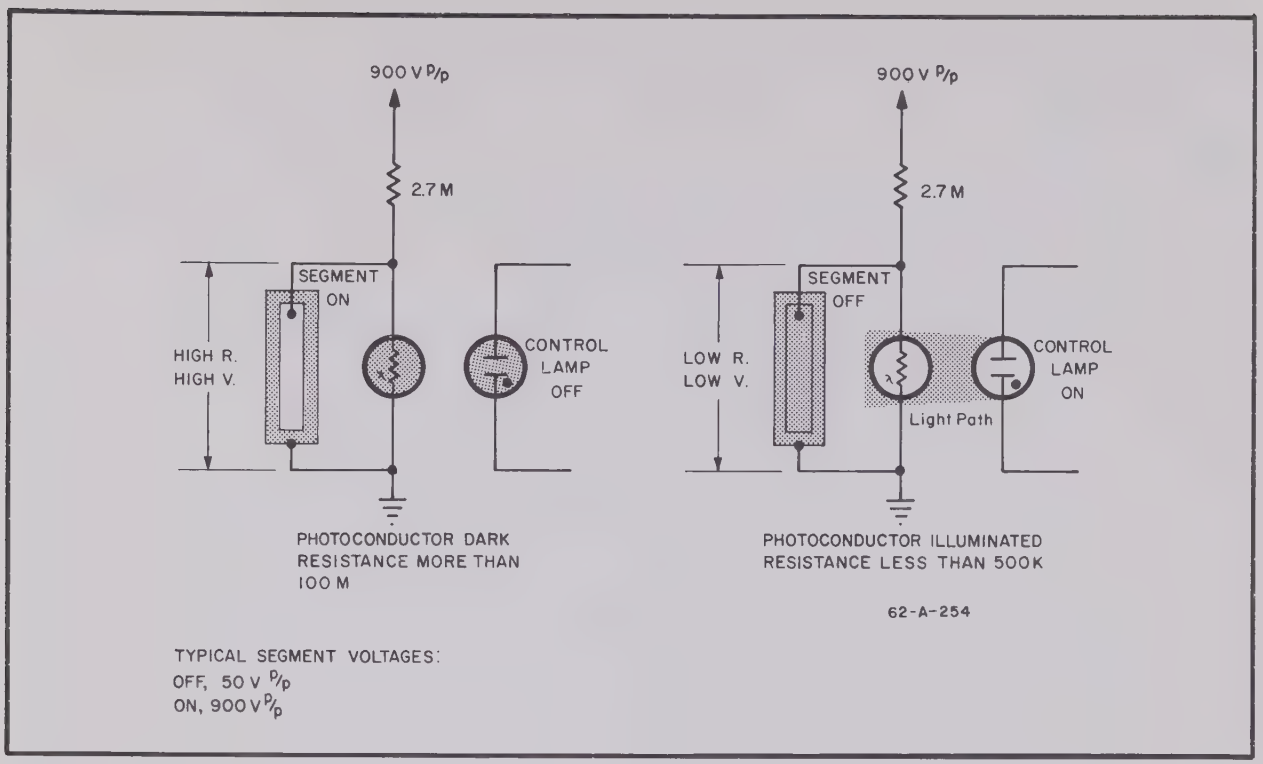


FIG. 3-5. The Basic Photoconductor Switching Circuit in Its Two States: Control Lamp "OFF", and Control Lamp "ON". "Low" and "High" are relative, not absolute, terms.

on Q3, but a negative voltage appears across R62 simultaneously, the negative voltage would override the positive voltage and turn Q3 and Q5 off. The schematic diagram shows in more detail the NOR logic that exists between the storage binaries and the lamp control transistors.

As described in Section 3.2, the storage circuit registers the decimal digits "0" through "9" as different voltage combinations on the collectors of the binaries. Using neon lamps, transistors, and photoconductors, the decoder converts the combinations into ON/OFF voltages controlling seven display segments on an electroluminescent panel.

Figure 3-5 shows the basic decoding circuit, which uses a photoconductor as the variable arm of a voltage divider. When the photoconductor is in total darkness, its internal resistance is more than 100 megohms. In the light of the neon "control" lamp, however, the resistance drops to less than 500K ohms. Thus, an electroluminescent segment connected across the photoconductor is switched on and off by the lamp.

The Decoder Block Schematic Diagram shows the complete decoder with its 16 control lamps. Lamp DS15 lights at all odd counts and turns off the lower segment (E) of the display. Lamp DS16 controls the decimal point (if one is used). Combinations of the other 14 lamps represent one registered count (0 through 9) and light at that count only.

Segment control is required for all digits except number 8. The lamps are enclosed with the photoconductors in a light-tight optical maze.

SECTION 4
PARTS LIST

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
C1	633-804717	Capacitor, F. Cerm., 0.01 μf, 500V	Sprague 29C9B5	1
CR1 thru CR6	755-402107	Diode, Special, 1N95	Beckman/Berkeley	6
DS1 thru DS16	825-414955	Lamp, Neon	B/B	16
Q1 thru Q6	755-410066	Transistor, Silicon, NPN	B/B	6
Q7 thru Q14	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	Sylvania 2N404	8
R1 thru R8	601-824112	Resistor, F. Comp, 2.7M, 1/4W, 10%	Allen Bradley CB2751	8
R9 & R10	601-023764	Resistor, F. Comp, 3.9K, 1W, 5%	Allen Bradley	2
R11	601-823956	Resistor, F. Comp, 150K, 1/4W, 10%	Allen Bradley CB1541	2
R12 & R13	601-800065	Resistor, F. Comp, 3.3K, 1W, 5%	Allen Bradley	2
R14		Same as R11		
R15 thru R17	601-822798	Resistor, F. Comp, 68K, 1/4W, 5%	Allen Bradley	6
R18	601-822337	Resistor, F. Comp, 91K, 1/4W, 5%	Allen Bradley CB9135	3
R19	601-823959	Resistor, F. Comp, 330K, 1/4W, 10%	Allen Bradley CB3341	4
R20	601-823962	Resistor, F. Comp, 560K, 1/4W, 10%	Allen Bradley CB5641	4
R21	601-822543	Resistor, F. Comp, 82K, 1/4W, 5%	Allen Bradley CB8235	2
R22		Same as R18		
R23		Same as R19		
R24		Same as R20		
R25 thru R27		Same as R15		
R28	601-822543	Resistor, F. Comp, 82K, 1/4W, 5%	Allen Bradley	1
R29		Same as R19		
R30		Same as R20		
R31 thru R33		Same as R15		
R34		Same as R21		
R35		Same as R19		

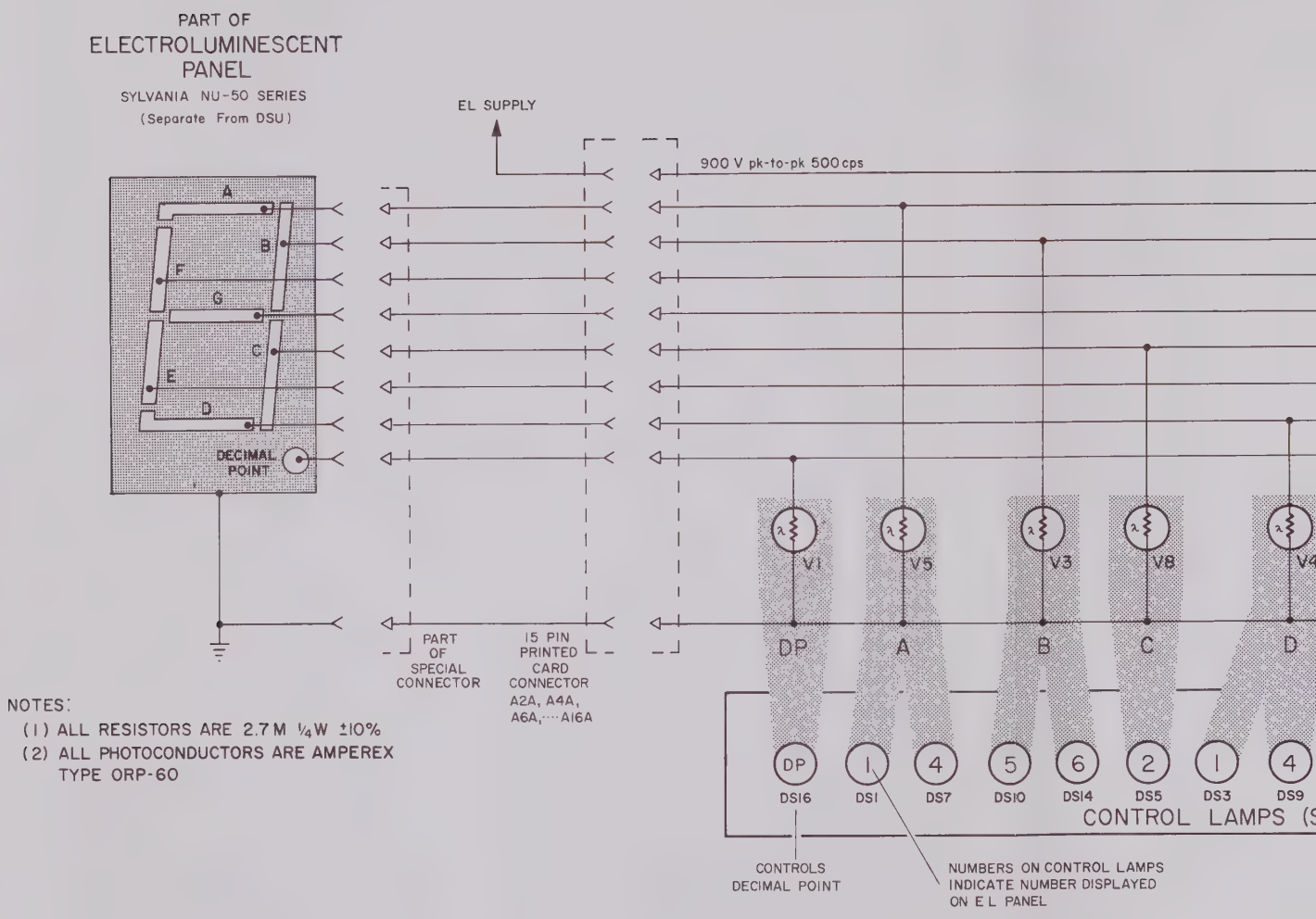
Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R36		Same as R15		
R37		Same as R18		
R38 thru R41	601-823963	Resistor, F. Comp, 680K, 1/4W, 10%	Allen Bradley CB6841	4
R42	601-823108	Resistor, F. Comp, 10K, 1/4W, 10%	Allen Bradley CB1031	6
R43 & R44	601-823942	Resistor, F. Comp, 3.3K, 1/4W, 10%	Allen Bradley CB3321	8
R45		Same as R42		
R46 & R47	601-823950	Resistor, F. Comp, 39K, 1/4W, 10%	Allen Bradley CB3931	12
R48 & R49		Same as R43		
R50 thru R53		Same as R46		
R54 & R55		Same as R43		
R56 & R57		Same as R46		
R58 & R59		Same as R43		
R60 thru R63		Same as R46		
R64 thru R71	601-822333	Resistor, F. Comp, 12K, 1/4W, 5%	Allen Bradley CB1235	8
R72	601-823109	Resistor, F. Comp, 33K, 1/4W, 10%	Allen Bradley CB3331	8
R73		Same as R42		
R74		Same as R72		
R75	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	Allen Bradley CB4721	4
R76	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 10%	Allen Bradley CB5621	4
R77		Same as R42		
R78 & R79		Same as R72		
R80		Same as R75		
R81		Same as R76		
R82		Same as R42		
R83 & R84		Same as R72		
R85		Same as R75		
R86		Same as R76		
R87		Same as R42		
R88 & R89		Same as R72		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R90		Same as R75		
R91		Same as R76		
R92		Same as R20		
V1 thru V8	753-416278	Photo-Resistor, END-View, Special	B/B	8
	864-412958	Pad, Connector, Transistor	B/B	14
	824-412922	Lamp Block, Base	B/B	1
	824-414475	Lamp Block, Cover	B/B	1

LOGIC SCALER
SCHEMATIC DIAGRAM

LOGIC SCALER
COUNTER CONTROL
SCHEMATIC DIAGRAM

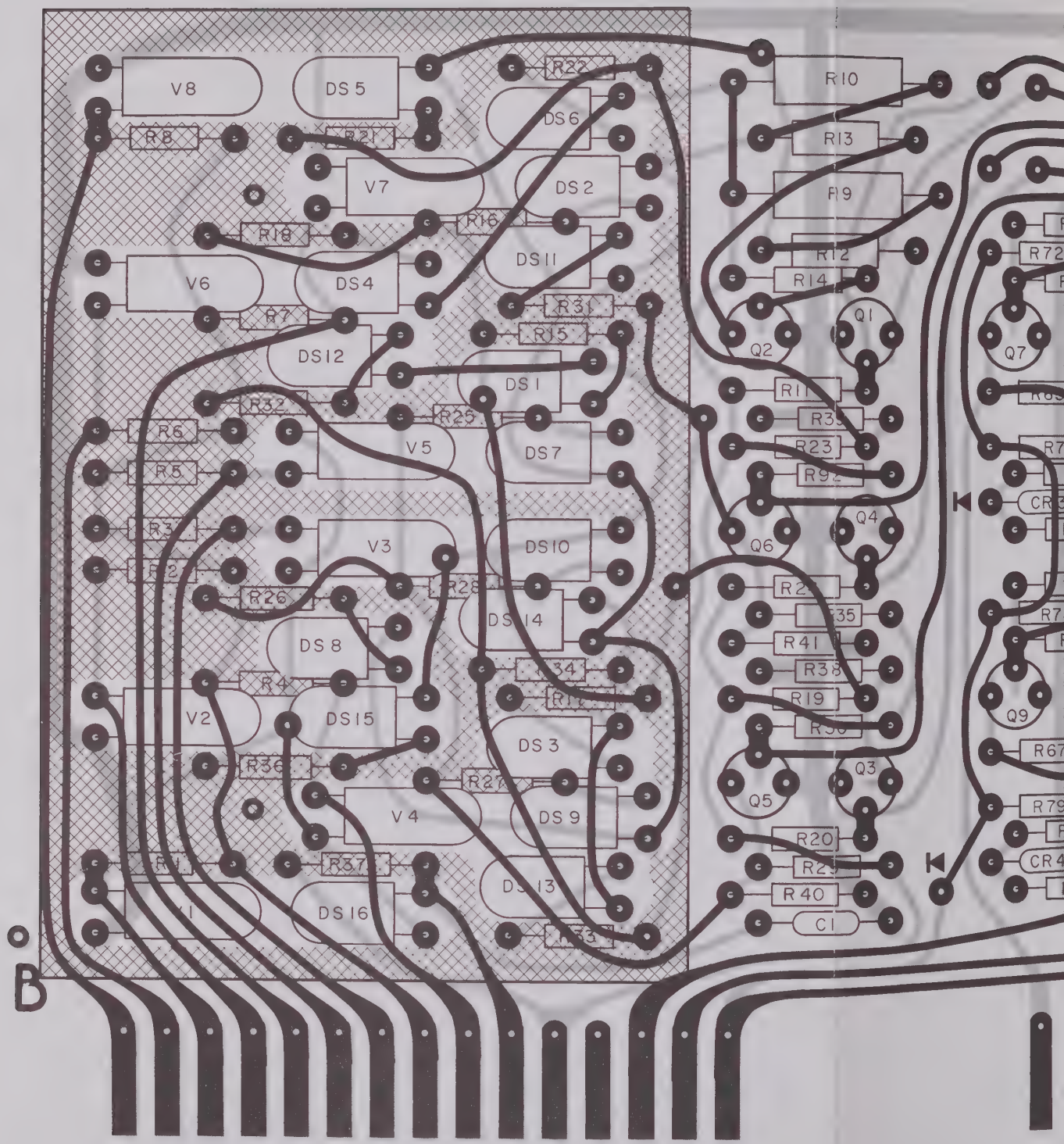
LOGIC SCALER
EMITTER FOLLOWER
SCHEMATIC DIAGRAM

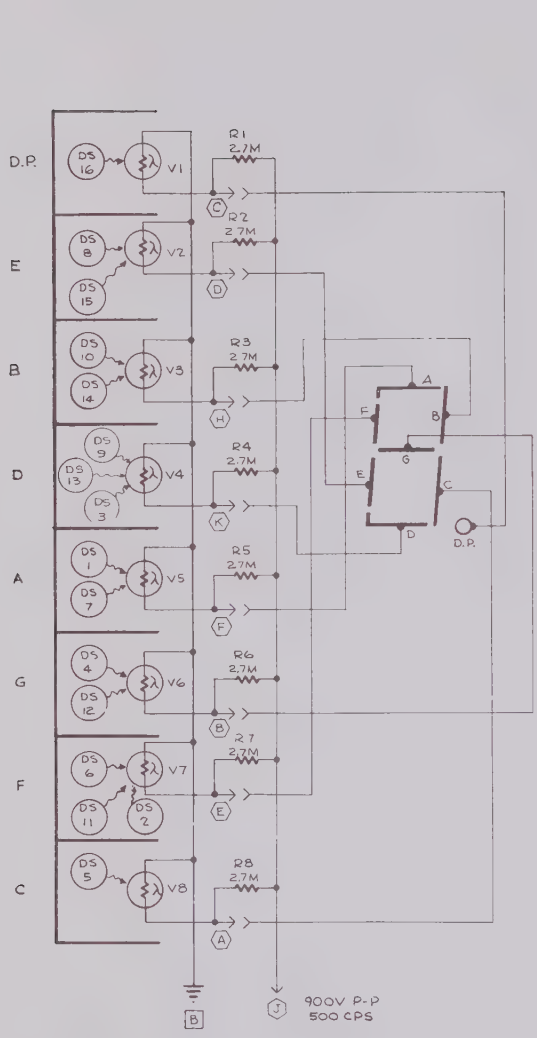


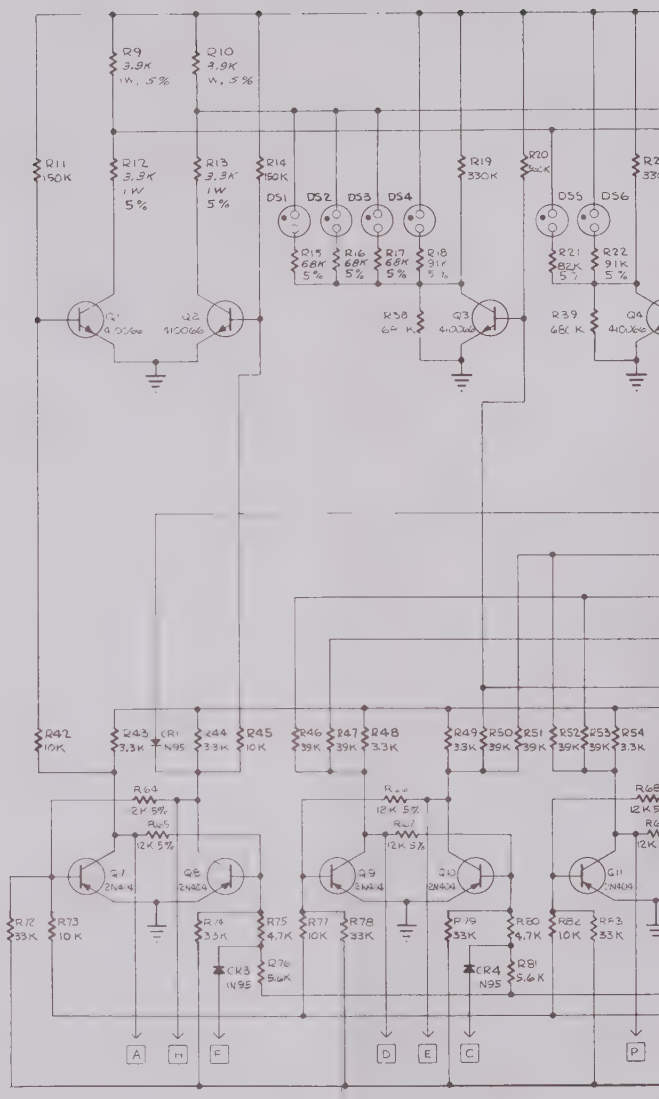
NOTES:

(1) ALL RESISTORS ARE 2.7 M ¼W ±10%

(2) ALL PHOTOCONDUCTORS ARE AMPEREX TYPE ORP-60


V8
DS5
R22
DS6
R8
R21
R10
R13
V7
DS2
R19
R16
R18
R12
R14
DS11
V6
DS4
R31
R7
R15
Q1
Q2
Q7
DS12
DS1
R11
R32
R25
R23
R6
V5
DS7
R5
Q4
Q6
V3
DS10
R26
R28
DS14
DS8
R4
R34
V2
DS15
DS3
R36
R27
Q3
Q5
V4
DS9
R20
R37
R40
DS16
C1
R33
Q9
R67
R79
CR4
B





NOTE:
1) ALL RESISTORS:
WATTAGE — 1/4W UNLESS NOTED
TOLERANCE — 10% UNLESS NOTED

2) ⬡ — INDICATES PINS OF P1 (FRONT CONNECTOR)

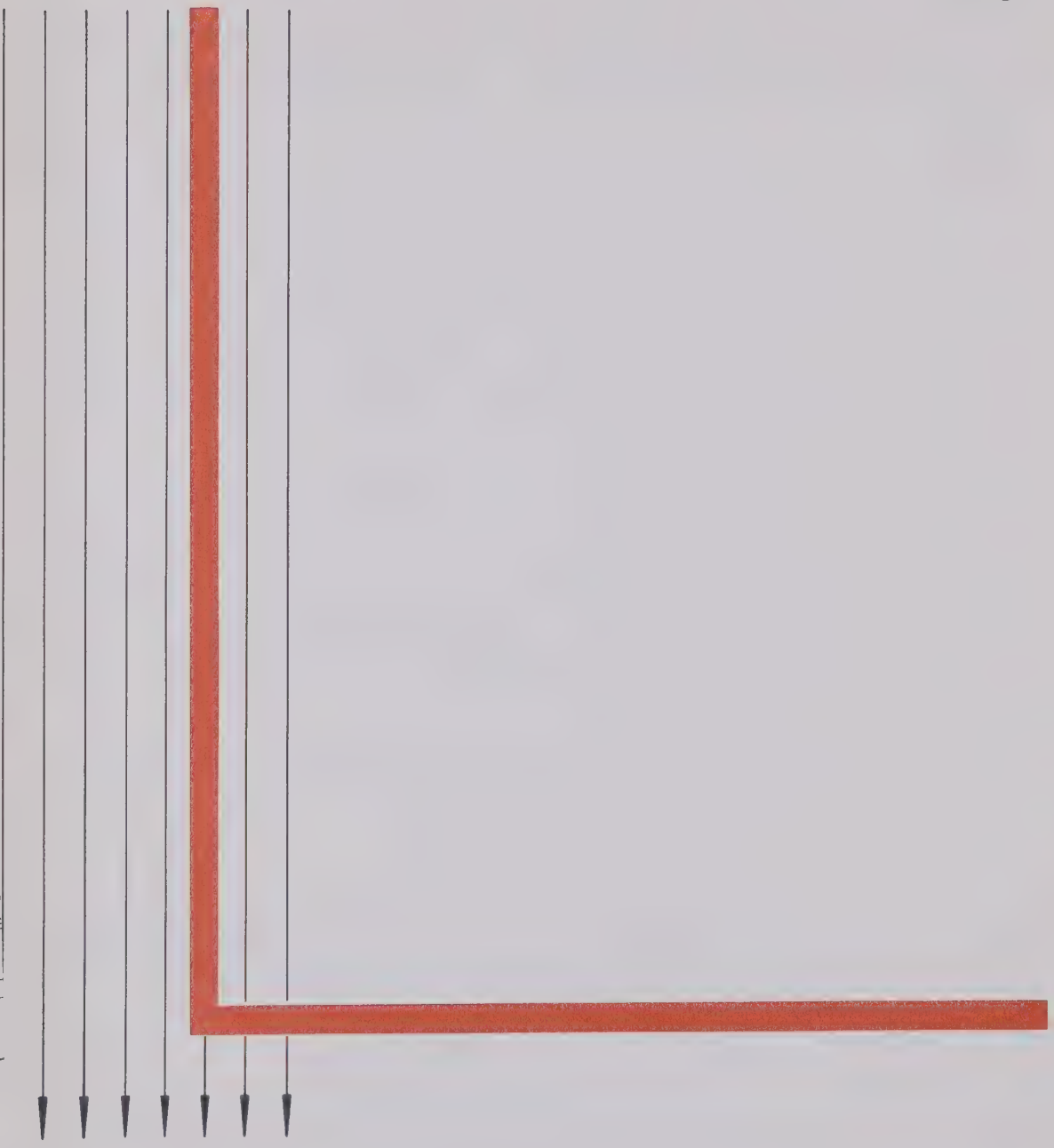
3) □ — " " " P2 (REAR CONNECTOR)

4) ALL PHOTORESISTORS (V1 THRU V8) ARE TO BECKMAN SPEC., DWG. 733-416278.

5) ALL NEON LAMPS (DS1 THRU DS16) ARE TO BECKMAN SPEC., DWG. 825-414955.

INSTRUCTION MANUAL

MODEL 850
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

December 1962

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

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(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

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Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

CONTENTS

		Page
SEC. 1	INTRODUCTION	
	1.1 General Description	1-1
	1.2 Technical Characteristics	1-1
SEC. 2	OPERATION	
	2.1 Mounting the Unit	2-1
	2.2 Supplying Power	2-1
	2.3 Supplying Input Signals	2-1
	2.4 Using Output Signals	2-1
	2.5 Resetting Counter to Zero	2-2
	2.6 Special Operating Conditions	2-3
SEC. 3	CIRCUITS	
	3.1 The Binaries	3-1
	3.2 The Scale-of-Ten Circuit	3-2
SEC. 4	PARTS LIST	

DIAGRAMS

Model 850 DCU Component Layout	3-3
Model 850 DCU Schematic (C411930-Rev. C)	

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 850 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit counts input pulses from zero to nine; each count is represented by output signals in binary (1-2-4-8) coded form. With an Electroluminescent Storage Unit this binary-coded output can be converted into a decimal digit display of the registered count.

At every tenth input pulse, the DCU generates an output signal suitable to drive another Model 850 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 TECHNICAL CHARACTERISTICS

Count Indication

Binary-coded (1-2-4-8) electrical signals

Input Requirements

Voltage pulse, +10 to +25 volts amplitude*, 1μs minimum duration (0.5μs rise time).

Maximum Counting Rate

250,000 counts per second

Resolution of Paired Pulses

3 microseconds

---

*The values given correspond to supply voltage levels listed under "Power Requirements". For values when other supply voltages are used, see Section 2.6.

Output Characteristics

Positive signal when count goes from "9" to "0", suitable for driving another Model 850 DCU.

Reset Requirement

Voltage pulse, -10 v amplitude*, 10μs minimum duration.

Power Requirements

22 ma at -15 v. (±5%)
2 ma at +10 v. (±5%)

(NOTE: The unit can operate at other voltage levels as well; see see Section 2.6).

Construction

Printed card plug-in unit (with 15-pin printed circuit connector).

Dimensions

1/2 inch wide, 3 11/16 inches high, 3 5/32 inches deep

Weight

1 1/2 oz.

*The values given correspond to supply voltage levels listed under "Power Requirements". For values when other supply voltages are used, see Section 2.6.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU can be mounted by plugging into a 15 pin printed-card-connector. Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

Ordinarily, the unit operates with supply voltages of -15 volts and +10 volts, but other voltage levels can be substituted as indicated in Section 2.6. The negative voltage supply should be connected to pin K of the DCU connector, while the positive supply should be connected to pin J.

2.3 SUPPLYING INPUT SIGNALS

Connect the source of input signals to pin C of the DCU connector. The unit will register a count each time a pulse +10 to +25 volts in amplitude (with a minimum width of 1μs and a 0.5μs rise time) is applied to the input terminal.

Pin A (capacitor bypass) provides an alternate input. If used, this input should be driven through an external capacitor.

2.4 USING OUTPUT SIGNALS

The DCU supplies readout signals to terminals D, F, M, and P of the DCU connector. These signals are in two voltage states: -12 volts with respect to ground (pin S) for the binary "one", and -0.3 volts with respect to ground for the binary "zero". The binary states (each binary driving one readout line) represent the registered count in 1-2-4-8 binary code. Each readout line will supply a maximum steady state current of 2 ma into a load connected to B-. Table 1 indicates the state of the binaries for each registered count from 0 to 9.

Use Table 1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weight. For example, the coded digit "1100" is equivalent to 1+2+0+0=3; and "0110" is equivalent to 0+2+4+0=6.

Table 1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

The readout signals at terminals D, F, M and P drive an Electroluminescent Storage Unit for a visual indication of the registered count. In addition, the output signal produced at terminal R each time the count goes from 9 to 0 can be used to drive another Model 850 DCU or other circuitry.

2.5 RESETTING DCU TO ZERO

Reset lines H, L, and N are clamped at zero volts while the DCU counts. A negative pulse to lines H and L (line N clamped at zero volts) will reset the DCU to zero. The DCU can be set to 9 by applying a negative pulse to lines L and N (line H clamped at zero volts). A 10 microsecond, -10 volt pulse will reset the DCU. The reset pulse can be generated either electronically by transistor circuitry or mechanically through relay contacts.

2.6 SPECIAL OPERATING CONDITIONS

Although the operating characteristics described in previous sections are for power supply levels of -15 and +10 volts, the unit will function at other voltages as well. Proper combinations of B- and B+ voltages down to -8 and +4 volts respectively can successfully be used.

Those characteristics which are affected by the supply voltage levels will naturally vary with the value of the voltages used. Thus, for example, with a B- and B+ voltage of -8 and +4 volts, the amplitudes of the input, output, and reset signals will be approximately as follows (signal widths remain unchanged):

1) Input signal: +5 to +15 volts

2) Output signal: Potentials of 0 and -6 volts with respect to ground.

3) Reset signal: -10 volts

SECTION 3

CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of p-n-p transistors connected in a scale-of-ten circuit. The transistor binaries are similar to vacuum tube binaries in that they have two stable states, and are alternately triggered from one state to the other by successive input pulses.

The major difference between the two types of binary is the operating characteristics of the transistors. In a transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low impedance allows a base current to flow and the transistor can conduct. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Consequently, no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input voltage pulse applied through diode CR3 to the base of Q2 drives this transistor to cutoff. As a result, the base current that normally flows is diverted and Q2, therefore, stops conducting.

The same input pulse which is applied to CR3 cannot change the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, the potential on its collector approaches B-. This change in voltage level, coupled through resistor R2 and capacitor C1 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R4 causes the potential on the collector to fall almost to zero. Under these conditions, the divider network consisting of R9 and R7 supplies a large enough positive potential to the base of Q2 to keep it cut off.

The binary, now in the "one" state, remains in this stable state until the next positive input pulse arrives. When this happens, Q1 is cut off, Q2 conducts, and the binary thus resumes its original state.

The collectors Q1, Q3, Q5, and Q7 are tied to terminals D, F, M, and P, respectively, of the DCU connector. A change in voltage level at each collector as the binary changes state is available as an output signal. In addition, one output of each binary is used as input to the following binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 850 DCU is actually a four-place binary counter wired so that it resets to zero on every tenth input pulse. Thus, for the first nine pulses, the binaries operate as in a conventional, 1-2-4-8 counter. At the count of eight, however, the negative potential on the collector of Q8 is fed back through R15 to the second binary. This places a bias on CR4 and CR5 so that the next positive pulse from Q2 will not trigger the second binary.

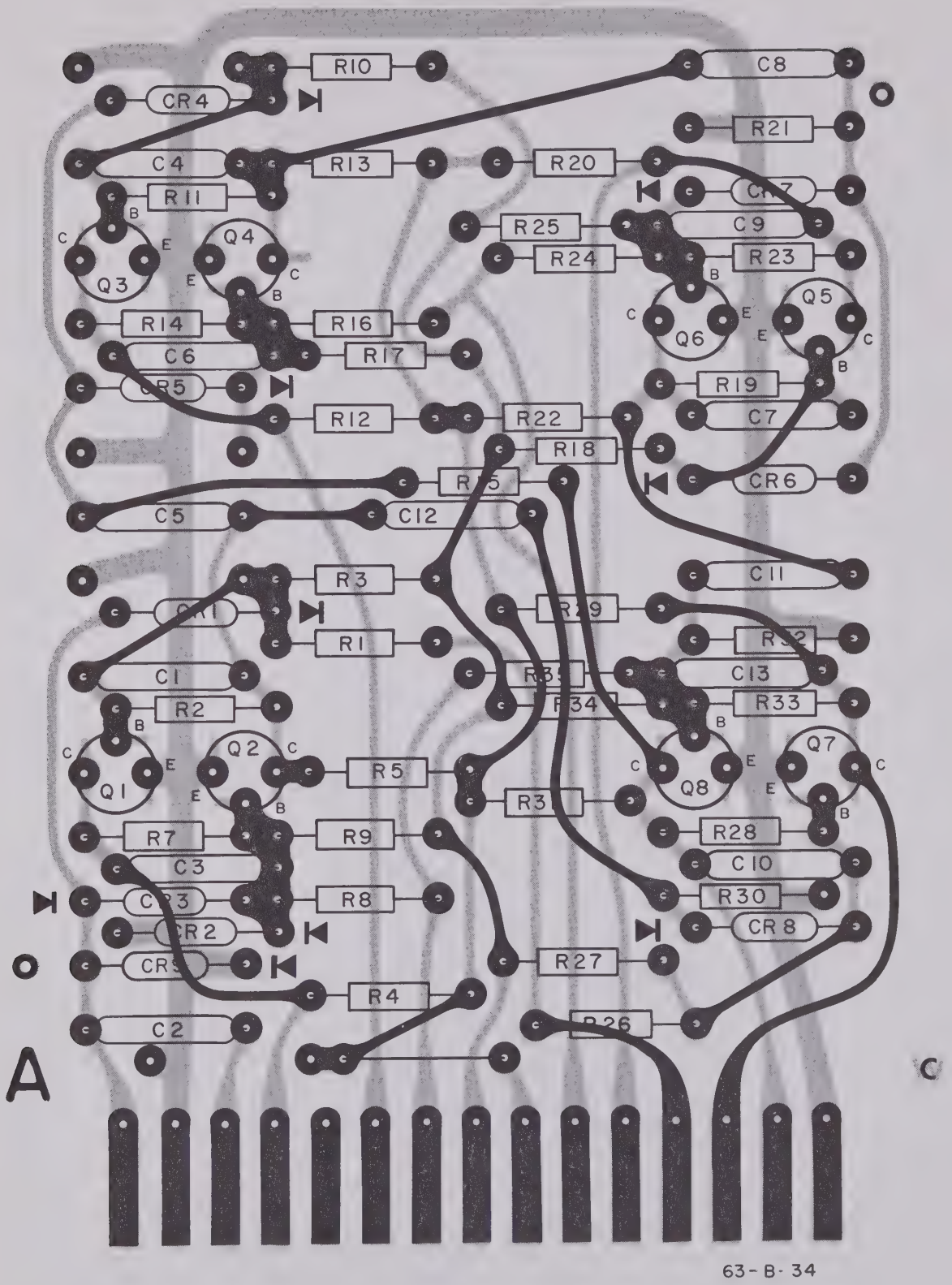
The tenth input pulse, then, flips the first binary to its "zero" state, but the corresponding positive transient at the collector of Q2 cannot trigger the second binary to the "one" state. However, this positive transient, coupled through C12 does trigger the fourth binary to its "zero" state.

At the tenth input pulse, therefore, all four binaries are in the "zero" state, the bias on CR2 and CR5 has been removed, and the circuit is ready for the next counting cycle.

The positive output signal from Q8, produced when the counter goes from nine to zero, can be used to drive another Model DCU. Thus, the DCU will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded form by the potentials on the binary readout lines. Only one output signal is available from each binary.

Reset lines H and L connect through a corresponding resistor to the base of the right-hand transistors (Q2, Q4, Q6, and Q8) of each binary. Reset line N connects to the base of the left-hand transistors (Q1 and Q7) of each binary. A negative voltage pulse applied to reset lines H and L (line N clamped at zero) will turn on all transistors on the right-hand side of each binary, setting the DCU to zero. A negative voltage pulse applied to reset lines L and N (line H clamped at zero) sets the DCU to nine.



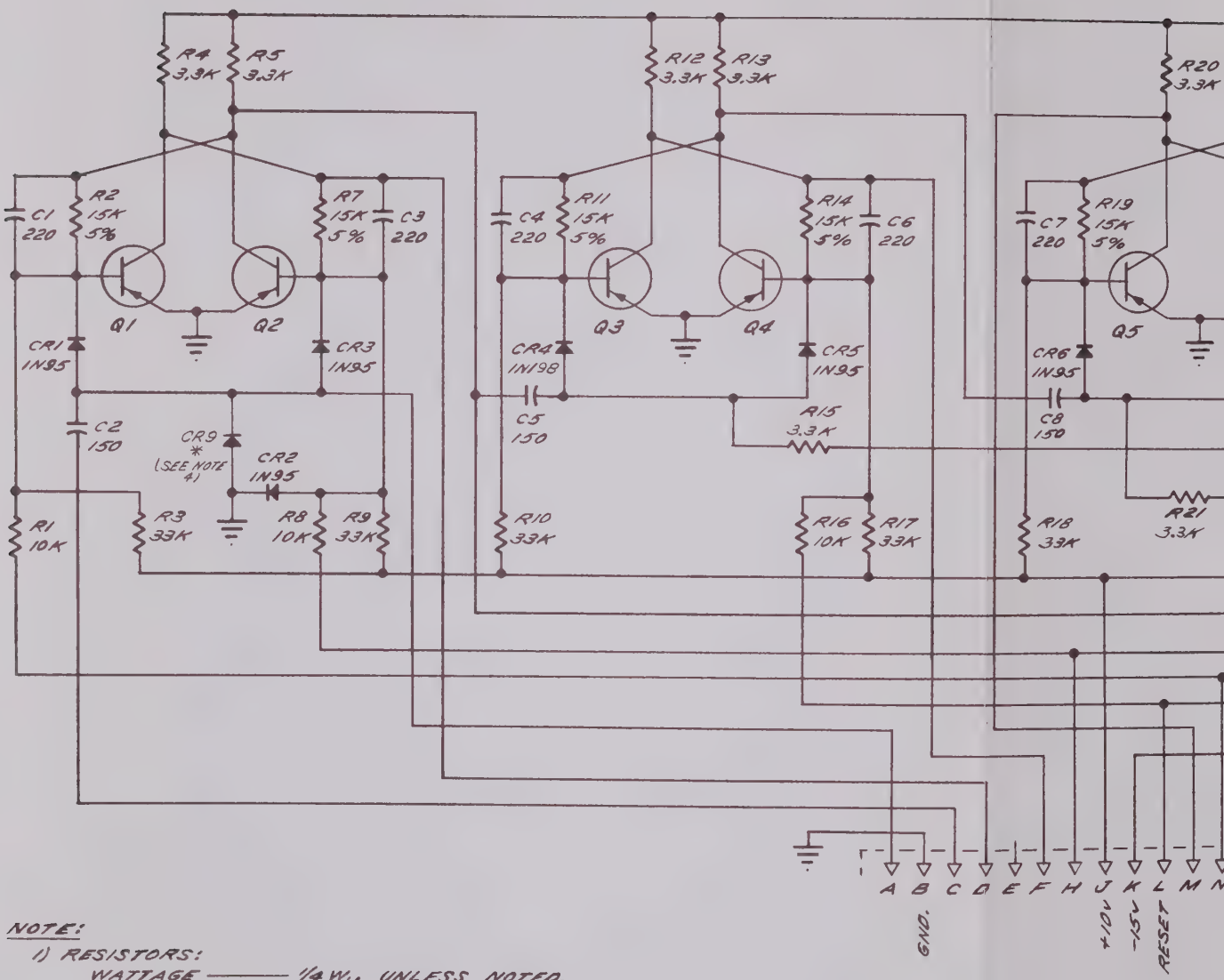
MODEL 850 DCU COMPONENT LAYOUT

SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty. / Ass'y
C1	637-824020	Capacitor, F. Mica, 220pf, 300V, 5%	9
C2	637-824018	Capacitor, F. Mica, 150pf, 300V, 5%	4
C3 & C4		Same as C1	
C5		Same as C2	
C6 & C7		Same as C1	
C8		Same as C2	
C9 thru C11		Same as C1	
C12		Same as C2	
C13		Same as C1	
CR1	755-402107	Diode, special	7
CR2 & CR3		Same as CR1	
CR4	755-800274	Diode, Germanium, 80 PIV, 4 ma, 1V min. fwd.	1
CR5 thru CR8		Same as CR1	
CR9	755-402107	Diode, special	1
Q1	755-800398	Transistor, Germanium, PNP, 150mw max.	8
Q2 thru Q8		Same as Q1	
R1	601-823108	Resistor, F. Comp., 10K, 1/4W, 10%	6
R2	601-822301	Resistor, F. Comp., 15K, 1/4W, 5%	8
R3	601-823109	Resistor, F. Comp., 33K, 1/4W, 10%	8
R4	601-823942	Resistor, F. Comp., 3.3K, 1/4W, 10%	12
R5		Same as R4	

Detail No.	Beckman Stock No.	Description	Qty. / Ass'y
R7		Same as R2	
R8		Same as R1	
R9 & R10		Same as R3	
R11		Same as R2	
R12 & R13		Same as R4	
R14		Same as R2	
R15		Same as R4	
R16		Same as R1	
R17 & R18		Same as R3	
R19		Same as R2	
R20 thru R22		Same as R4	
R23		Same as R2	
R24		Same as R1	
R25		Same as R3	
R26		Same as R1	
R27		Same as R3	
R28		Same as R2	
R29 thru R32		Same as R4	
R33		Same as R2	
R34		Same as R3	
R35		Same as R1	
	864-412958	Pad, converter transistor	8



NOTE:

1) RESISTORS:
   - WATTAGE ——— 1/4 W., UNLESS NOTED.
   - TOLERANCE ——— 10%, " " .
2) CAPACITORS:
   - CAPACITY ——— IN Pf, " " .
   - VOLTAGE ——— 300 v, " " .
   - TOLERANCE ——— 5%, " " .
3) TRANSISTORS ARE — 2N404.

4) * DIODE IS BECKMAN SPEC. 755-402107.

Beckman INSTRUMENTS, INC.
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(415) 526-7730; TWX: 415-236-8933

Effective Oct. 1, 1965

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Electronics Instrument Department
★ **Montreal 16, Quebec, Canada**
2442 Trenton Avenue
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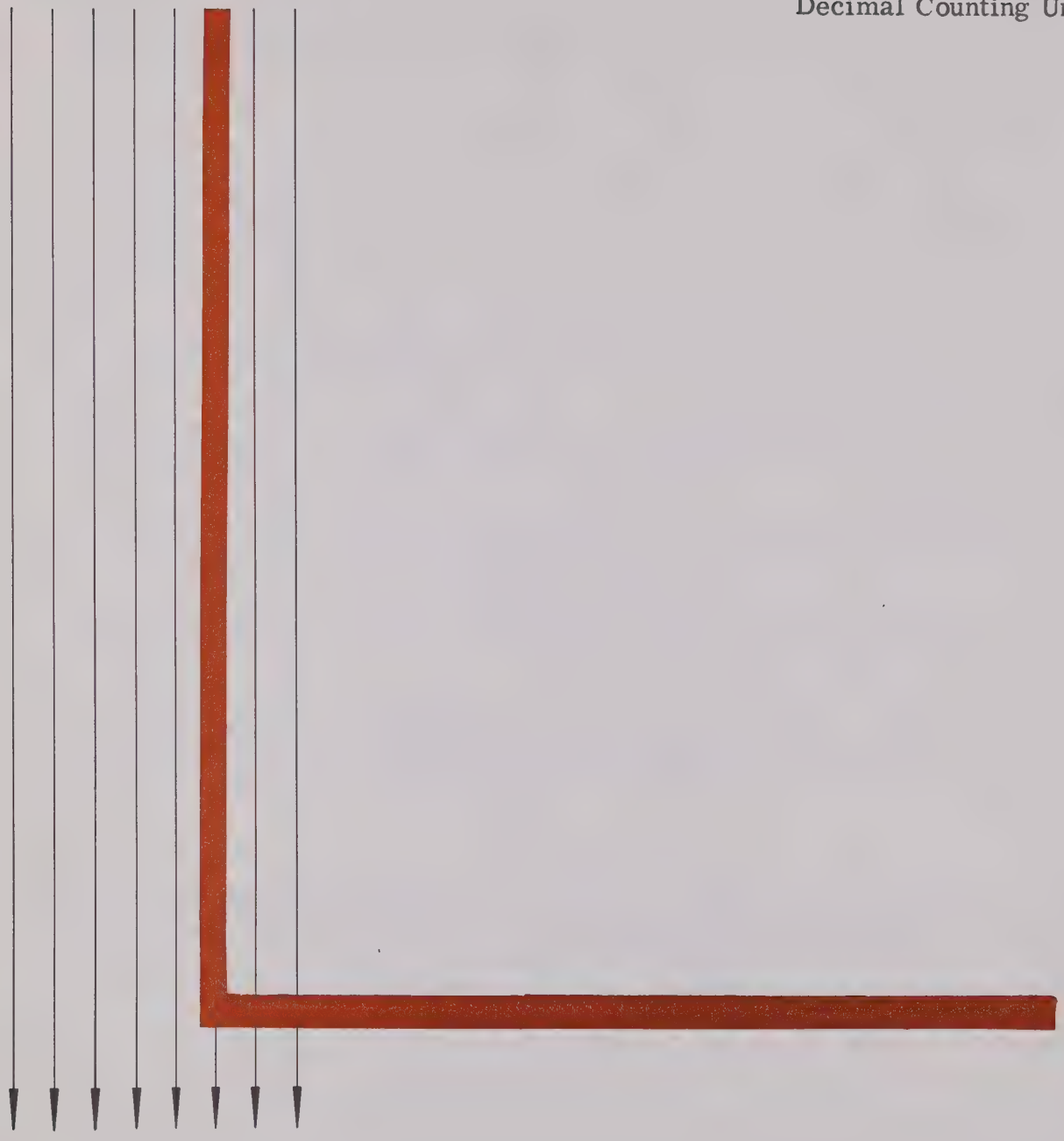
TWX: 610-421-3564

INSTRUCTION MANUAL

MODEL 872
Decimal Counting Unit



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Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
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CONTENTS

		Page
SEC. 1	INTRODUCTION	
	1.1 General Description	1-1
	1.2 Specifications	1-1
SEC. 2	OPERATION	
	2.1 Mounting the Unit	2-1
	2.2 Supplying Power	2-1
	2.3 Supplying Input Signals	2-1
	2.4 State of the Binaries	2-1
	2.5 Using Output Signals	2-2
	2.6 Resetting Unit to Zero	2-2
SEC. 3	CIRCUITS	
	3.1 The Binaries	3-1
	3.2 The Scale-of-Ten Circuit	3-2
	3.3 The Gate Circuit	3-4
SEC. 4	PARTS LIST	

Model 872 Schematic Diagram, Dwg. No. D416913-Rev. B

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 872 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit provides a count of input pulses from zero to nine, each count being represented by output signals in 1-2-4-8 binary-coded decimal form. With a Data Storage Unit (DSU), this binary-coded decimal output can be converted into a decimal digit display of the registered count.

At every tenth input pulse the DCU generates an output signal that can be used to drive a Model 862 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 SPECIFICATIONS

See Table 1-1.

Table 1-1

Input Requirements	Positive pulse 0.7 volt minimum to 1.0 volt maximum amplitude from a source impedance of 180 ohms or less. Pulse duration of 10 nanoseconds minimum, 20 nanoseconds maximum.
Counting Rate	0 - 50 mc.
Count Indication	Use with DSU for visual indication of stored count.

continued.

Table 1-1 - continued

Output Characteristics	1) 1-2-4-8 permuted binary code. 2) Emitter-follower output with 1.5KΩ emitter resistance to -15 volts. 3) Carry pulse designed to drive a following Model 862 or 850 DCU. 4) One output is available from each binary: -0.2 volt for binary 1, -6.0 volts for binary 0. Each binary will supply 2 ma to the DSU.
Gating Requirements	10 to 30 ma, depending on amplitude of input pulse, required to inhibit counting.
Transfer Time	15 nanoseconds between application of 10th input pulse and start of output pulse.
Reset to Zero	Accomplished by negative pulse or voltage level change. Reset line held at 0 volts. At reset, line is driven to -10 volts for 1 microsecond, minimum.
Power Requirements	100 ma at -15 volts, and 7 ma at +10 volts.
Operating Temperature	-20°C to +65°C.
Construction	Etched wire module with circuitry on both sides using "plated-through" component holes.
Transistors	Four specially selected, high speed switching units: four 2N961, two 2N709, soldered into circuit.
Dimensions	1/2" wide, 3-11/16" high, 3-5/32" deep.
Weight	1-3/4 oz.
Connector Required	Typical: Ucinite 119510-MC-15C. Beckman Stock No. 680-815353.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU plugs into a 15-pin printed-circuit card connector Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

The unit operates with supply voltages of -15 volts and +10 volts. The negative voltage supply connects to pin K of the DCU connector, while the positive supply connects to pin J.

2.3 SUPPLYING INPUT SIGNALS

Connect the source of input signals to pin A of the DCU connector. The unit will register a count each time a pulse meeting the requirements listed in Table 1-1, Input Requirements, is applied to the input terminal Gate current is applied to pin C.

2.4 STATE OF THE BINARIES

At the collectors of the "normally-on" transistors, -6.0 volts indicates the corresponding binary is in the "one" state, while -0.2 volt represents the "zero" state. Table 2-1 indicates the binary states for each registered count from 0 to 9.

Use Table 2-1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weights. For example, the coded digit "1100" is equivalent to 1+2+0+0 = 3; and "1001" is equivalent to 1+0+0+8 = 9.

2.5 USING OUTPUT SIGNALS

The unit provides readout signals in the form of high and low potentials at terminals D, F, M, and P of the DCU connector. These signals can be used to drive any external load within the specifications listed in Table 1-1, Output Characteristics.

For example, the readout signals at terminals D, F, M, and P can be used to drive a Data Storage Unit for a visual indication of the registered count. In addition, the output signal supplied to terminal R each time the count goes from 9 to 0 can drive a Model 862 or 850 DCU.

Table 2-1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

2.6 RESETTING UNIT TO ZERO

While counting, the reset line (terminal L) must be clamped at 0 volts. Applying a 1 microsecond, -10 volt pulse to terminal L of the DCU will effect reset. The reset voltage can be generated either electronically by transistor circuitry or mechanically through relay contacts.

SECTION 3

CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of PNP transistors, connected in a scale-of-ten circuit. The binaries have two stable states and are alternately triggered from one state to the other by successive pulses. Transistors Q3 and Q10 are emiiter followers to isolate the first and fourth binaries, respectively, from their ac load.

In a PNP transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Therefore, no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input pulse applied through diode CR5 to the base of Q2 drives this transistor to cutoff.

The pulse applied to CR5 is also applied to CR3, but does not affect the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, its collector potential approaches -6 volts. This change in voltage level, coupled through resistor R5 and capacitor C3 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R1 causes the collector potential to fall to almost zero. Under these conditions the diode base clamp CR6 with divider network R2 and R6 maintains a positive potential at the base of Q2 to keep it cut off.

The binary, now in the "one state, remains in this stable state until the next positive input pulse arrives. At that time, Q1 cuts off, Q2 conducts, and the binary resumes its original state.

The collector of each "normally off" transistor in the four binaries connects to a corresponding terminal of the DCU connector. Thus, the change in voltage level at each collector, as the binary changes state, is available as an output signal. The change in voltage level at the collector of each "normally on" transistor is used as the drive signal to the next binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 872 DCU is a four-place binary counter wired so that it resets to zero on every tenth input pulse. Operation is explained in detail in the following paragraphs.

3.2.1 Initial Conditions and Circuit Fundamentals

Under initial conditions, transistors Q2, Q5, Q7, and Q9 are saturated. Transistors Q1, Q4, Q6, and Q8 are cut off. These conditions define the "zero" state for each binary.

At this point, a review of transistor binary (flip-flop) circuit fundamentals may be helpful in understanding the circuit description in the following paragraphs.

Consider the first binary, comprising transistors Q1 and Q2. Under initial conditions, Q1 is cut off and Q2 is saturated. Q1 is held at cutoff by divider network R3, R5, and clamp CR2. A positive input pulse applied at the junction of CR3 and CR5 has no effect on Q1, since it is already cut off. While Q2 is saturated, its collector is near ground potential. Now, when the positive input pulse is applied through CR5 to the base of Q2 it drives Q2 into cutoff and the collector potential of Q2 rises to approximately -6 volts. This negative transient, coupled to the base of Q1 through crossover network R5 and C3, drives Q1 into saturation.

Thus, on the first input pulse, the first binary flips and its transistors reverse their states. But the second binary is not affected, since it takes a positive output pulse coupled through emitter follower Q3 from the first binary to cause the second binary to flip.

But on application of the second input pulse, circuit action produces a positive output signal to flip the second binary as follows: the positive input pulse goes through CR3 to the base of Q1 to cut it off. As Q1 cuts off, its collector potential rises to approximately -6 volts. This negative transient couples to the base of Q2 through crossover network R2 and C1 driving it into saturation. When Q2 saturates, the collector potential goes from approximately -6 volts to approximately -0.2 volt. This positive-going pulse passes through emitter follower Q3 to trigger the second binary. To summarize: a positive pulse applied to the first binary will cut off the saturated transistor and regenerative action will drive the cut-off transistor into saturation. The first binary will produce a driving pulse to the second binary only when the second transistor of the first binary goes from cutoff to saturation. Thus, the first binary will produce an output pulse only on every second input pulse, even though every input pulse will reverse the state of the binary. These principles apply to all of the binaries.

3.2.2 Sequence of Operation

Pulse No.	Action
1	First binary flips. Q2 turns off. No output signal.
2	First binary flips. Q2 saturates. Output pulse coupled through Q3 flips second binary. Q5 turns off.
3	First binary flips. Q2 turns off. No output signal.
4	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q5 saturates. Output pulse from Q5 flips third binary and Q7 cuts off.
5	First binary flips. Q2 turns off. No output signal.
6	First binary flips. Q2 saturates. Output signal from Q2 flips second binary. Q5 turns off. No output pulse from Q4.
7	First binary flips. No output from Q2.
8	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q5 saturates. Output pulse from Q5 flips third binary. Q7 saturates. Output pulse from Q7 flips fourth binary. Q9 cuts off. Negative 6.5 volts at collector of Q9 is applied to CR9 and CR11 closing the gate.
9	First binary flips. No output from Q2.
10	First binary flips. Q2 saturates. Output signal from Q2 is blocked from the second binary by closed gate CR9 and CR11. So it goes through C15 and CR21 to flip the fourth binary. Q9 saturates. The output pulse from Q9 goes through emitter follower Q10 to DCU output pin R.

3.2.3 Summary

At the tenth input pulse, all four binaries are in the "zero" state and the DCU is ready for the next counting cycle. The positive output signal from transistor Q10, produced when the counter goes from nine to zero, can be used to drive a Model 862, 860, or 850 DCU. Thus, the counter will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded decimal form by the potentials on the readout lines of the binaries.

The reset line connects through a corresponding resistor to the base of the normally-on transistors (Q2, Q5, Q7, and Q9) in each binary. A negative voltage pulse to the reset line will cause the normally-on transistors to conduct and thus trigger all binaries to the zero state.

3.3 THE GATE CIRCUIT

The gate circuit, consisting of diodes CR24 and CR4, allows the Model 872 DCU to be controlled by an external current source to inhibit counting. With a dc current of 30 ma flowing from pin C, for example, the pulse source driving the input (pin A) would be required to supply 30 ma more than was originally needed to trigger the first binary. This high threshold level thus inhibits counting for all but extremely high current pulses.

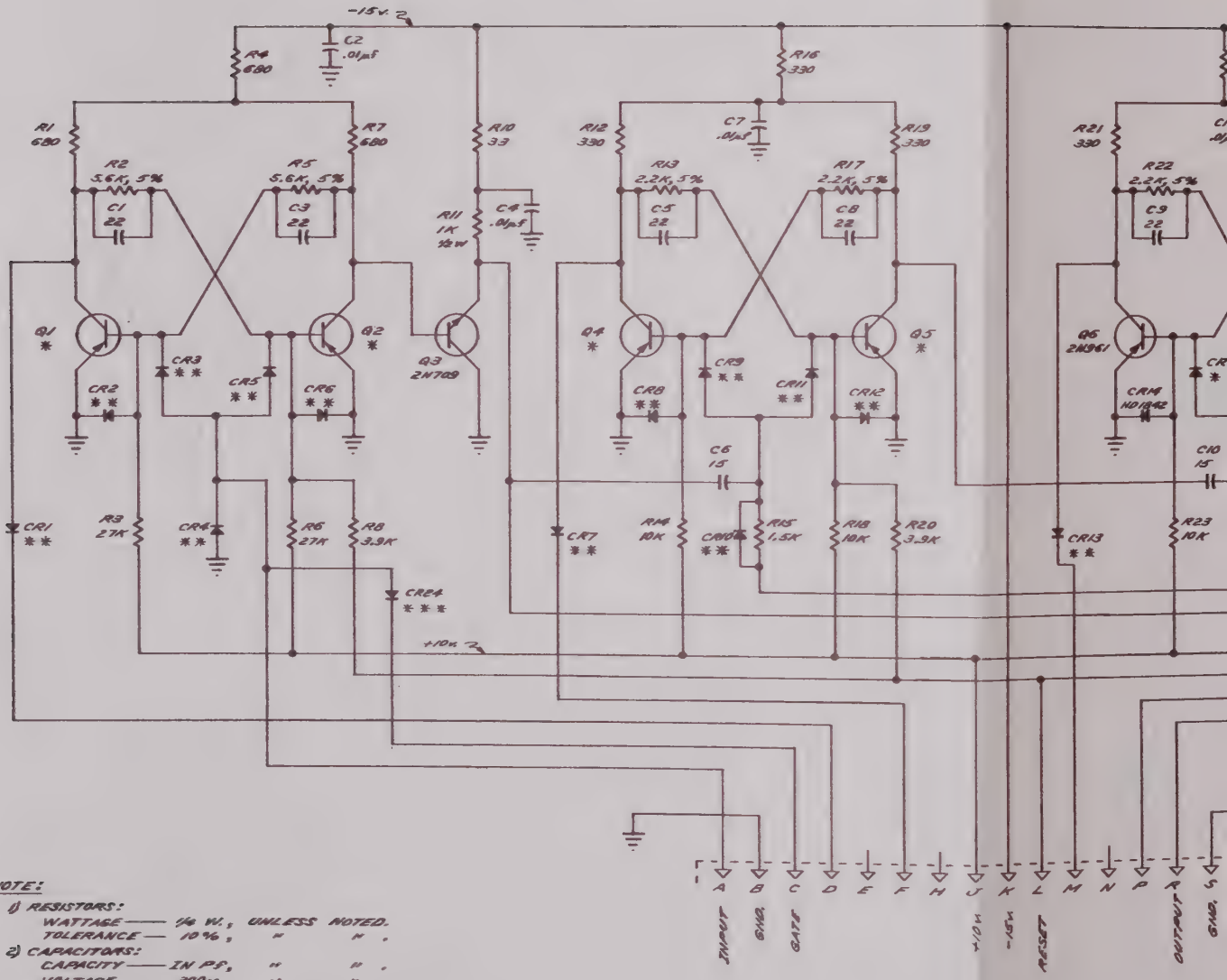
SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	8
C2	633-804717	Capacitor, F. Cerm., 0.01μf, 500V, -20% +80%	6
C3		Same as C1	
C4		Same as C2	
C5		Same as C1	
C6	637-824006	Capacitor, F. Mica, 15pf, 300V, 5%	3
C7		Same as C2	
C8 & C9		Same as C1	
C10		Same as C6	
C11		Same as C2	
C12		Same as C1	
C13	637-824004	Capacitor, F. Mica, 10pf, 300V, 5%	1
C14		Same as C1	
C15		Same as C6	
C16		Same as C2	
C17		Same as C1	
C18		Same as C2	
CR1	755-817250	Diode, Germanium, 6 PIV, 200ma, 1V min. fwd.	20
CR2 thru CR13		Same as CR1	
CR14	755-824300	Diode, Germanium, type HD1842	3
CR15		Same as CR1	
CR16		Same as CR14	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
CR17		Same as CR1	
CR18		Same as CR14	
CR19 thru CR23		Same as CR1	
CR24	755-815561	Diode, Silicon, 75 PIV, 10ma, 1V min. fwd.	1
Q1	755-417294	Transistor, special	4
Q2		Same as Q1	
Q3	755-819906	Transistor, Silicon, NPN, 300mw	2
Q4 & Q5		Same as Q1	
Q6	755-817811	Transistor, Germanium, PNP, 150mw	4
Q7 thru Q9		Same as Q6	
Q10		Same as Q3	
R1	601-823937	Resistor, F. Comp., 680Ω, 1/4W, 10%	3
R2	601-822397	Resistor, F. Comp., 5.6K, 1/4W, 5%	2
R3	601-823949	Resistor, F. Comp., 27K, 1/4W, 10%	2
R4		Same as R1	
R5		Same as R2	
R6		Same as R3	
R7		Same as R1	
R8	601-823943	Resistor, F. Comp., 3.9K, 1/4W, 10%	4
R10	601-823923	Resistor, F. Comp., 33Ω, 1/4W, 10%	1
R11	601-008076	Resistor, F. Comp., 1K, 1/2W, 10%	1
R12	601-823935	Resistor, F. Comp., 330Ω, 1/4W, 10%	9
R13	601-822328	Resistor, F. Comp., 2.2K, 1/4W, 5%	6
R14	601-823108	Resistor, F. Comp., 10K, 1/4W, 10%	6
R15	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	2
R16		Same as R12	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R17		Same as R13	
R18		Same as R14	
R19		Same as R12	
R20		Same as R8	
R21		Same as R12	
R22		Same as R13	
R23		Same as R14	
R24		Same as R12	
R25		Same as R13	
R26		Same as R14	
R27		Same as R12	
R28		Same as R8	
R29		Same as R12	
R30		Same as R13	
R31		Same as R14	
R32		Same as R12	
R33		Same as R13	
R34		Same as R14	
R35		Same as R12	
R36		Same as R8	
R37	601-823925	Resistor, F. Comp., 47Ω, 1/4W, 10%	1
R38		Same as R15	
	864-412958	Pad, Transistor	10

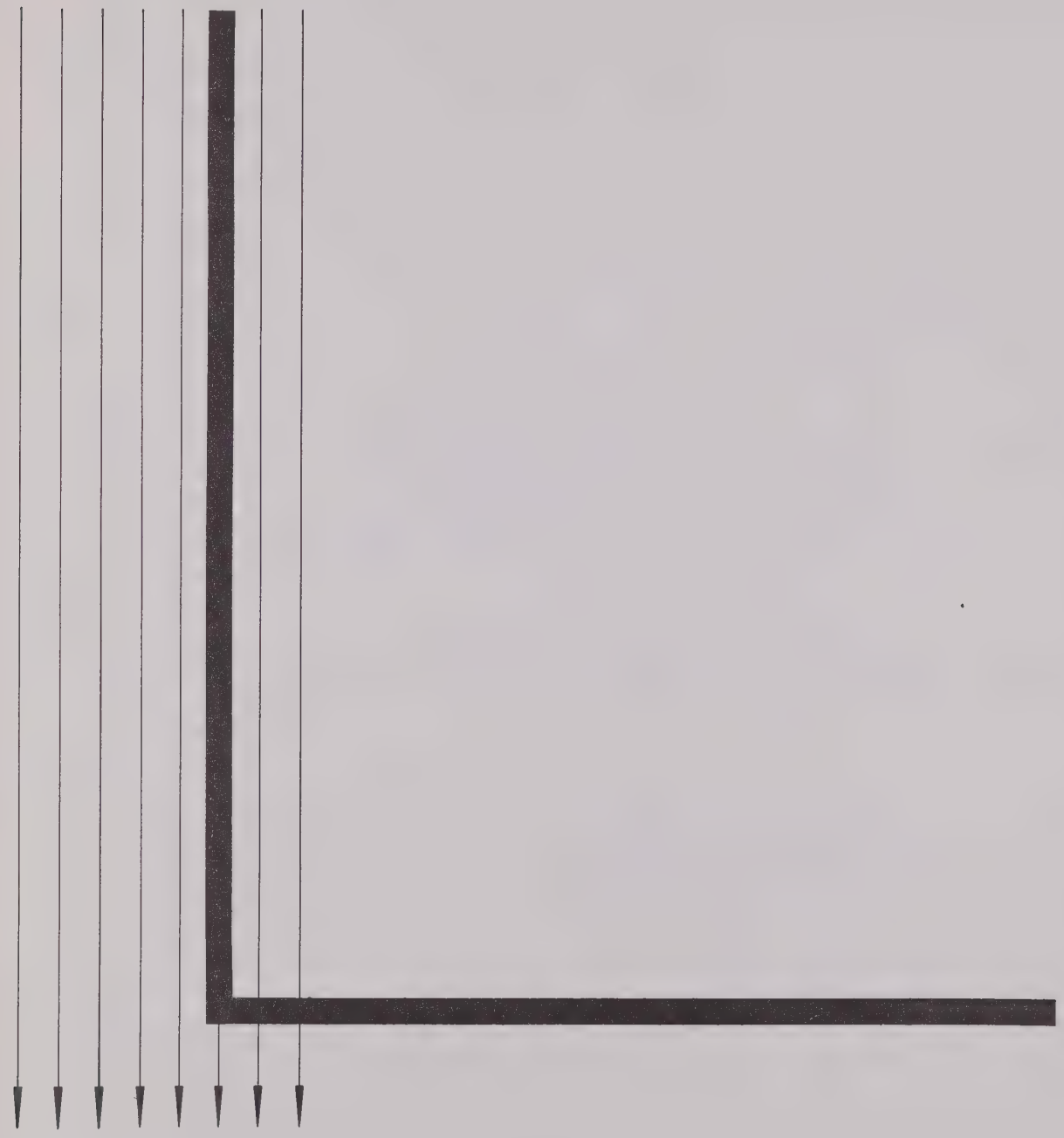


NOTE:

1) RESISTORS:
   WATTAGE —— 1/4 W., UNLESS NOTED.
   TOLERANCE —— 10%, " "
2) CAPACITORS:
   CAPACITY —— IN P.F., " "
   VOLTAGE —— 300v., " "
   TOLERANCE —— 5%, " "
3) .01μF DISC ARE -20+80%, 500v.
4) * — TRANSISTORS ARE TO BECKMAN SPEC. DWG. A755-417234
5) ** — DIODES ARE TO BECKMAN PART Nº 755-817250.
6) *** — DIODE TO BECKMAN SPEC. PART Nº 755-815561.

INSTRUCTION MANUAL

MODEL 862
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

November 1963

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Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

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(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

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(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

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REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

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CONTENTS

		Page
SEC. 1	INTRODUCTION	
	1.1 General Description	1-1
	1.2 Specifications	1-1
SEC. 2	OPERATION	
	2.1 Mounting the Unit	2-1
	2.2 Supplying Power	2-1
	2.3 Supplying Input Signals	2-1
	2.4 Using Output Signals	2-1
	2.5 Resetting DCU to Zero	2-2
SEC. 3	CIRCUITS	
	3.1 The Binaries	3-1
	3.2 The Scale-of-Ten Circuit	3-2
SEC. 4	PARTS LIST	

Model 862 Schematic Diagram, Dwg. No. D416916-Rev. A

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 862 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit provides a count of input pulses from zero to nine, each count being represented by output signals in binary (1-2-4-8) coded decimal form. With a Data Storage Unit (DSU) this binary-coded output can be converted into a decimal digit display of the registered count.

At every tenth input pulse, the DCU generates an output signal suitable to drive a Model 862 or a Model 860 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 SPECIFICATIONS

See Table 1-1.

Table 1-1.

Count Indication	Binary-coded decimal (1-2-4-8) electrical signals.
Input Requirements	Positive pulse or voltage step, 6 volts to 8 volts amplitude (+7.0 recommended), 10 nanoseconds rise-time. Pulse duration 30 nanoseconds, minimum.
Counting Rate	0 - 5 mc.

continued.

Table 1-1 - continued

Output Characteristics	1-2-4-8 permuted binary code. Output available from one side of each binary. Voltage levels +0.2 volts and -9.0 volts. Binaries designed to drive maximum of 2 ma through 7.5K to the negative supply of -15 volts. Carry pulse output designed to drive a following Model 862 or 860 DCU. Designed to drive 1.5 ma into DSU from "off" side of binaries.
Reset Requirements	Negative pulse or voltage level change. Reset time held at 0 volts. At reset, line is driven to -10 volts for 10 microseconds.
Power Requirements	60 ma at -15 volts and 4.0 ma at +10 volts.
Transfer Time	60 nanoseconds between application of tenth input pulse and start of output pulse.
Transistors	Germanium: eight 2N961 and, one 2N1143.
Dimensions	1/2" wide, 3-11/16" high, 3-5/32" deep.
Weight	1-1/2 oz.
Connector Required	UCINITE 119510-MP-15C. Beckman Stock No. 680-815353.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU plugs into a 15-pin printed-card connector. Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

Ordinarily, the unit operates with supply voltages of -15 volts and +10 volts. The negative voltage supply connects to pin K of the DCU connector, and the positive supply to pin J. Supply voltage tolerance ±10%.

2.3 SUPPLYING INPUT SIGNALS

Connect the input signal to pin C of the DCU connector. The unit registers a count each time a pulse +6 to +8 volts in amplitude (with a minimum width of 30 nanoseconds and 10 nanoseconds rise time) is applied to the input terminal.

Pin A (capacitor bypass) provides an alternate input. If used, this input should be driven through an external capacitor.

2.4 USING OUTPUT SIGNALS

Each of the DCU's four binaries supply readout signals in two forms: with a B- supply of -15 volts, -12 volts with respect to ground (pin S) for a binary "one", and -0.3 volts with respect to ground for a binary "zero". The binary states of "one" or "zero" indicate the registered count in 1-2-4-8 binary coded decimal. Each readout line will supply a maximum steady state current of 2 ma into a load connected to B-. Table 2-1 represents the binary state for each registered count from 0 to 9.

The readout signals at terminals D, F, M, and P, can be used to drive the DSU for a visual indication of the registered count. In addition, the output signal produced at terminal R each time the count goes from 9 to 0 can drive either a Model 860 or 862 DCU, or other circuitry.

Table 2-1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

Use Table 2-1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weights. For example, the coded digit "1010" is equivalent to 1+0+4+0 = 5; and "1001" is equivalent to 1+0+0+8 = 9.

2.5 RESETTING DCU TO ZERO

Reset line (pin L) is clamped at zero volts while the DCU counts. Applying a negative pulse to pin L resets the DCU to zero.

SECTION 3

CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of PNP transistors, connected in a scale-of-ten circuit. The binaries have two stable states and are alternately triggered from one state to the other by successive input pulses.

In a PNP transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Consequently, no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input pulse applied through diode CR4 to the base of Q2 drives this transistor to cutoff.

The pulse applied to CR2 and CR4 has no effect on the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, the potential on its collector approaches B-. This change in voltage level, coupled through resistor R5 and capacitor C3 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R1 causes the potential on the collector to fall to almost zero. Under these conditions, the diode base clamp CR5 combined with the divider network R2 and R6 maintains a positive potential at the base of Q2 to keep it cut off.

The binary, now in the "one" state, remains in this stable state until the next positive input pulse arrives. At that time, Q1 cuts off, Q2 conducts, and the binary resumes its original state.

The collector of each "normally off" transistor in the four binaries connects to a corresponding terminal of the DCU connector. Thus, the change in voltage level at each collector, as the binary changes state, is available as an output signal. The change in voltage level at the collector of each "normally on" transistor is used as the drive signal to the next binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 862 DCU is a four-place binary counter wired so that it resets to zero on every tenth input pulse. Operation is explained in detail in the following paragraphs.

3.2.1 Initial Conditions and Circuit Fundamentals

Under initial conditions, transistors Q2, Q4, Q6, and Q8 are saturated. Transistors Q1, Q3, Q5, and Q7 are cut off. These conditions define the "zero" state for each binary.

At this point, a review of transistor binary (flip-flop) circuit fundamentals may be helpful in understanding the circuit description in the following paragraphs.

Consider the first binary, transistors Q1 and Q2. Under initial conditions, Q1 is cut off and Q2 is saturated. Transistor Q1 is held at cutoff by divider network R3, R5, and clamp CR1. A positive input pulse applied at the junction of CR2 and CR4, has no effect on Q1 since it is already cut off. While Q2 is saturated, its collector is near ground potential. Now, when the positive input pulse is applied through CR4 to the base of Q2, it drives Q2 into cutoff and the collector potential decreases to approximately -12 volts. This negative transient, coupled to the base of Q1 through crossover network R5 and C3, drives Q1 into saturation.

Thus, on the first input pulse, the first binary "flips" and its transistors reverse their states. But the second binary is not affected since it takes a positive output pulse from the binary to cause the second binary to flip.

But on application of the second input pulse, circuit action produces a positive output signal to flip the second binary, as follows: the positive input pulse goes through CR2 to the base of Q1 to cut it off. As Q1 cuts off, its collector potential drops to approximately -12 volts. This negative transient, coupled to the base of Q2 through crossover network R2 and C1, drives Q2 into saturation. When Q2 saturates, the collector potential goes from approximately -12 volts to approximately -0.2 volts. This positive transient passes through C6 and CR8 to trigger the second binary. To summarize: a positive pulse applied to the first binary will cut off the saturated transistor, and regenerative action will drive the cutoff transistor into saturation. The first binary will produce a driving pulse to the second binary only when the second transistor of the first binary goes from cutoff to saturation. Thus, the first binary will produce an output pulse only on every second input pulse, even though every input pulse will reverse the state of the binary. These principles apply to all of the binaries.

3.2.2 Sequence of Operation

Pulse No.	Action
1	First binary flips. Q2 turns off. No output signal.
2	First binary flips. Q2 saturates. Output pulse flips second binary. Q4 turns off.
3	First binary flips. Q2 turns off. No output signal.
4	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary and Q6 cuts off.
5	First binary flips. Q2 turns off. No output pulse from Q2.
6	First binary flips. Q2 saturates. Output signal from Q2 flips second binary. Q4 turns off. No output pulse from Q4.
7	First binary flips. No output signal from Q2.
8	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary. Q6 saturates. Output pulse from Q6 flips fourth binary. Q8 cuts off. Negative 12 volts at collector of Q8 is applied to CR9 and CR6 closing the gate.
9	First binary flips. No output from Q2.
10	First binary flips. Q2 saturates. Output signal from Q2 is blocked from second binary by closed gate CR9 and CR6. So it goes through C14 and CR9 to flip the fourth binary. Q8 saturates. The output pulse from Q8 goes through emitter follower Q9 to output (pin R).

3.2.3 Summary

At the tenth input pulse, all four binaries are in the "zero" state and the DCU is ready for the next counting cycle. The positive output signal from transistor Q8, produced when the counter goes from nine to zero, can drive a Model 860 or 862 DCU. Thus, the counter will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded decimal form by the potentials on the readout line of the binaries.

Reset line L connects to the base of the normally-on transistors (Q2, Q4, Q6, and Q8) in each binary. A negative voltage pulse applied to these reset lines will cause the normally-on transistors to conduct and trigger all binaries to the zero state.

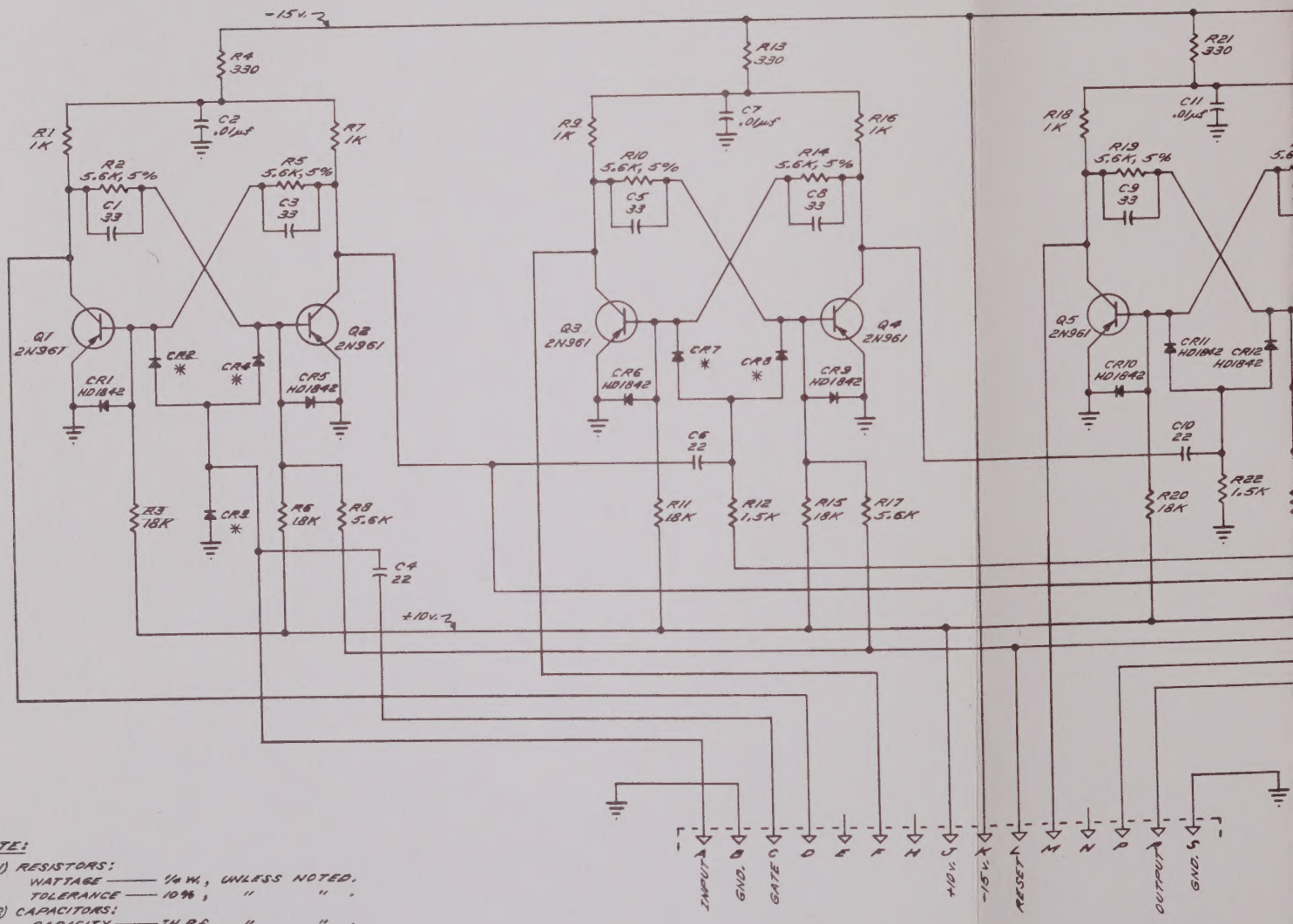
SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	637-824010	Capacitor, F. Mica, 33pf, 300V, 5%	8
C2	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	4
C3		Same as C1	
C4	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	5
C5		Same as C1	
C6		Same as C4	
C7		Same as C2	
C8 & C9		Same as C1	
C10		Same as C4	
C11		Same as C2	
C12		Same as C1	
C13		Same as C4	
C14		Same as C1	
C15		Same as C4	
C16		Same as C2	
C17		Same as C1	
CR1	755-824300	Diode, Germanium, type HD1842	11
CR2	755-815561	Diode, Silicon, 75 PIV, 10ma, 1V min. fwd.	5
CR3 & CR4		Same as CR2	
CR5 & CR6		Same as CR1	
CR7 & CR8		Same as CR2	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
CR9 thru CR16		Same as CR1	
Q1	755-817811	Transistor, Germanium, PNP, 150mw	8
Q2 thru Q8		Same as Q1	
Q9	755-823145	Transistor, Germanium, PNP, 300mw, max.	1
R1	601-823111	Resistor, F. Comp., 1K, 1/4W, 10%	8
R2	601-822397	Resistor, F. Comp., 5.6K, 1/4W, 5%	8
R3	601-823948	Resistor, F. Comp., 18K, 1/4W, 10%	8
R4	601-823935	Resistor, F. Comp., 330Ω, 1/4W, 10%	4
R5		Same as R2	
R6		Same as R3	
R7		Same as R1	
R8	601-823944	Resistor, F. Comp., 5.6K, 1/4W, 10%	4
R9		Same as R1	
R10		Same as R2	
R11		Same as R3	
R12	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	3
R13		Same as R4	
R14		Same as R2	
R15		Same as R3	
R16		Same as R1	
R17		Same as R8	
R18		Same as R1	
R19		Same as R2	
R20		Same as R3	
R21		Same as R4	
R22		Same as R12	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R23		Same as R2	
R24		Same as R3	
R25		Same as R1	
R26		Same as R8	
R27		Same as R1	
R28		Same as R2	
R29		Same as R3	
R30		Same as R4	
R31		Same as R12	
R32		Same as R2	
R33		Same as R3	
R34		Same as R1	
R35		Same as R8	
R36		Same as R4	
R37	601-008079	Resistor, F. Comp., 1.8K, 1/2W, 10%	1
	864-412958	Pad, Transistor	9



NOTE:

1) RESISTORS:
   WATTAGE ——— 1/2 W., UNLESS NOTED.
   TOLERANCE ——— 10% , " " .
2) CAPACITORS:
   CAPACITY ——— IN P.F, " " .
   VOLTAGE ——— 300 v., " " .
   TOLERANCE ——— 5% , " " .
3) .01μf DISC ARE -20+80%, 500 v.
4) * - DIODES ARE TO BECKMAN SPEC. PART NO 755-815561.